Analysis of Air Force Aircraft Multiyear Procurements with Implications for the B-2

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PREFACE

The U.S. Congress mandated in Public Law 100-456 that the Office of the Secretary of Defense (OSD) institute a program management initiative for the B-2 Advanced Technology Bomber Program. The Deputy Under Secretary of Defense (Strategic and Theater Nuclear Forces) asked The RAND Corporation to provide research and analytic support for an OSD strategy to reduce B-2 procurement costs. The study was sponsored by the Director of Defense Research and Engineering.

As part of the RAND effort, this report examines several past uses of multiyear procurement contracting by the Air Force to develop indicators of program stability useful in determining if a program is an appropriate candidate for multiyear procurement contracting. The report reviews the KC-10, F-16, and B-1B multiyear procurement contracts regarding perceived risks, contractual arrangements to reduce or allocate those risks, and estimated cost reductions. Comparisons are made between experiences on these procurements. The indicators are then demonstrated on the B-2 program.

To ensure the widest possible distribution of this report, the discussion is based entirely on unclassified sources.

This research was done in the Acquisition and Support Policy Program of RAND's National Defense Research Institute, a federally funded research and development center sponsored by OSD and the Joint Chiefs of Staff.

SUMMARY

The Air Force suggested in 1988 that the B-2 Advanced Technology Bomber, currently in low rate production, be produced using a multiyear procurement contract (MYPC). In light of the suggestion for a B-2 MYPC, the Deputy Under Secretary of Defense (Strategic and Theater Nuclear Forces) tasked The RAND Corporation to examine the past uses of MYP contracting to develop indicators of program stability that could be used in an assessment of whether a program was a reasonable candidate for MYP contracting. As part of this response, we reviewed Air Force aircraft MYPCs: the KC-10, the F-16, and the B-1B. We compared the perceived risks at the time of the MYPC commitment, contractual arrangements to reduce or allocate those risks, and cost reductions achieved. We used this information to develop indicators of program instability that might be applied to a potential B-2 MYPC as well as other future MYPC proposals.

PROGRAM STABILITY

In approving MYPCs, Congress wants to know whether the program is stable and can produce the cost avoidance estimated as a result of MYP contracting. In this report we develop indicators of requirements, funding, design, and cost stability—all knowable in advance of a MYP contracting decision—for assessing program stability. These indicators include expected changes in the threat environment, consistent service commitment to the requirement, OSD and congressional support, the existence or expectation of competing technologies, expected changes in the defense budget, historical funding turbulence, program integration responsibility, number of MYPC primes, major new technology incorporated, status of test flight program, production runs completed, number of aircraft completed, major new manufacturing processes used, number of aircraft produced on the full production line, and inflation. We compare the values of these indicators for our case studies with the following results.

The B-1B program showed greater signs of instability at the time of its MYPC than did the other two procurements. B-1B assessments at the time, however, did not flag these uncertainties. Of the three programs, the B-1B had more subsequent problems than the other two programs. Although not canceled, the B-1B program had technical and performance difficulties that have added to the cost of the program.

The KC-10 and the F-16 MYPCs were executed on time and within the budget, and they met performance expectations.

CONTRACT TERMS

The contractual terms included in an MYPC can also be used as indicators of program stability. The type of contract, the contract arrangements for profits, and special clauses all address specific risks in a procurement. Our analysis indicates that contracts offer a reliable image of how risky a procurement is.

- Use of a fixed-price incentive contract with a high percentage difference between the target cost and the ceiling indicates design or cost uncertainty.
- A share line that imposed the least cost overrun risk on the contractor, say 90/10 rather than 60/40, indicates design or cost uncertainty.
- Warranty clauses that limit contractor responsibility and engineering change proposal (ECP) clauses that allow for renegotiation if the government changes the system design indicate the design is unstable and performance remains unknown.
- Extensive and specific economic price adjustment (EPA) clauses indicate the economic outlook is uncertain.
- Generous indemnification, cancellation, and termination clauses indicate requirements or funding are unstable.

We reviewed the relevant contracts with the System Program Offices and contractors to determine why certain clauses were used and how the clauses protected them. The various contractual terms indicate that the KC-10 and the F-16 were treated as less risky programs than the B-1B. The contractual terms show the KC-10 and F-16 contractors willing to bear a greater share of contractual risks than the B-1B contractors, except the engine contract. The B-1B contracts show that the parties were aware of possible instability in the program at the time of the MYPC and used contract terms to allocate these risks.

COST REDUCTIONS ASSOCIATED WITH MYP CONTRACTING

The primary motivation for using an MYP contracting strategy is to reduce costs associated with production. Cost estimation is an art, and circumstances can easily create a bias in estimates of cost reduction

that favor MYP contracting. Keeping this difficulty in mind, we reviewed the case study procurements to determine how cost avoidance was estimated.

We found that vendor procurement and manufacturing offered the greatest potential for real cost reduction under an MYP strategy. Inflation avoidance provides considerable reductions only if one ignores the cost to the government of borrowing money.

Congress has indicated that MYP contracting should be used only if it results in cost avoidance of at least 12 percent over an annual contract. All past Air Force aircraft MYPCs expected less than 12 percent in cost avoidance in then-year dollars and less than 9 percent using present value.

APPLICATION TO A B-2 MYPC PROPOSAL

A B-2 MYPC exhibit has not been presented to Congress and much program information remains classified. We do not know if an MYPC will be proposed. However, the indicators we used to assess past MYP programs can be used to flag uncertainties in the current B-2 program that will raise serious doubts about an MYPC commitment if these uncertainties remain.

The indicators developed from past MYPCs show that if the B-2 program was reviewed for stability as of the summer of 1990, many existing areas of instability would have to be addressed before an MYPC commitment. These include a changing threat, eroding political support, lack of commitment to production quantity and rates, an expected decline in the defense budget, funding turbulence, incomplete design testing, no full rate annual production run, and substantial new manufacturing technology incorporated into the production process.

If an MYPC proposal is drafted, the contracts immediately preceding the MYPC and the MYPC proposal can be analyzed for further indications of program instability. If the level of uncertainty is high and the precedent of the B-1B contract is followed, a B-2 MYPC would use a fixed-price incentive agreement with a high ceiling and a share line that reduces overrun risks for the contractor. It might call for successive pricing. It would have limited warranties and generous cancellation and indemnification clauses. A contract proposal of this type indicates that considerable risk associated with instability remains in the program.

Even if instability remains and the production quantity is severely cut, an MYPC might allow for attractive cost reductions. If the B-2 followed the pattern of other procurements, the cost avoidance would

not meet the 12 percent congressional threshold. The absolute reductions, however, might be large. Congress would then have to assess whether it was willing to accept the risk burden of the contract terms to realize the potential cost avoidance. The outcome of this assessment would depend on Congress's willingness to reduce its funding flexibility in a time of budget contractions.

ACKNOWLEDGMENTS

The authors are grateful to several people for support on this research. Colonel Arnold Michalke and Fred Reinhard of the Office of the Under Secretary of Defense for Acquisition provided insight and guidance on the project. In addition, the research required input from many members of the System Program Offices at Wright Patterson and from representatives of prime contractors and subcontractors. These people all gave freely of their time, and their help is greatly appreciated. Within RAND, Amy Praskac and Lue Pope provided research support. Comments and insights from our colleagues John Birkler, James Dertouzos, Edmund Dews, Ronald Hess, Susan Resetar, Michael Rich, Curt Rogers, and Giles Smith greatly improved the content of this report.

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I. INTRODUCTION

Built by Northrop Corporation, the stealth bomber was publicly unveiled on November 22, 1988, and flew its first test flight on July 10, 1989. This test flight heralded a new era of stealth technology. In hearings before the House Armed Services Committee, Secretary Cheney quoted the price of the B-2 program of 132 aircraft at $70.2 billion, a price that shocked some in Congress.[1]

The Air Force, in an effort to reduce program costs, planned for the use of a multiyear procurement contract (MYPC) for the B-2 production phase.[2] The use of MYP contracting has both potential rewards and risks. On the benefit side, MYP contracting is supposed to reduce the cost of military procurements by providing the funding stability needed to produce more efficiently. However, in undertaking MYP contracting, the government bears the risk of cancellation or higher unit cost because of changes in requirements, budget priorities, technical problems, and cost overruns. Moreover, the commitment reduces the flexibility of Congress and the Department of Defense (DoD) to respond to a changing environment.

Because MYP contracting is not without risk, Congress requires that MYPCs for major systems such as the B-2 be approved by the Office of the Secretary of Defense (OSD) and the U.S. Congress. Congress reviews proposed candidates for indications of program instability and cost reductions before approval. Exhibits or submissions from the sponsoring service provide very limited information on program stability. This information usually takes the form of "high," "medium," or "low" values for program stability without further explanation.

PROJECT PURPOSE

As part of the program management initiative mandated by Congress, the Under Secretary of Defense for Acquisition (USDA) tasked The RAND Corporation to review past Air Force experiences with MYP contracting for applications relevant to the B-2 procurement. USDA is responsible for reviewing MYPC proposals before

[1]"Cheney: HASC Actions Lead to More Costly, Less Robust Defense," *Aerospace Daily*, July 14, 1989, p. 1.

[2]MYPC refers to multiyear procurement contracts as specific contracts. MYP or MYP contracting refers to the procurement environment and not to a particular contract.

submittal to Congress and was interested in assessing if a program was an appropriate candidate for MYP contracting, particularly whether contractual arrangements could be used as indicators of stability. This interest was sparked by the scant information currently provided by the services on program stability. Although the immediate application of any method would be for the B-2, in fact methods for assessing remaining program stability could be used for future MYPC proposals as well.

We were to explore the relationship between the requirements, technical, and cost risks of past programs and the contractual vehicle used to allocate those risks during the production phase. If the contractual arrangements did indeed reflect program risk, then proposed MYP contractual arrangements could be used to indicate further areas of remaining program risk. Specifically

- What were the indicators of program and cost uncertainties in past MYPCs when Congress committed to them?
- How did contractual arrangements address these risks?
- How do the indicators of stability on past programs compare with indicators for the current B-2 program?

This report documents the project findings. We review the KC-10, F-16, and B-1B procurements for perceived risks at the time of the MYPC commitment, estimated cost reductions (the benefits of the MYPCs), and the translation of risks into contractual arrangements. From this we developed a set of indicators that could be used to assess if an aircraft procurement program is appropriate for MYP contracting according to congressional criteria of stability. We then apply these indicators to the B-2 procurement, as it now stands, to demonstrate the usefulness of the indicators and to show areas of instability in the program about which Congress should be concerned.

The Air Force has not submitted a formal proposal for a B-2 MYPC. We do not know if it will be submitted, given changes in the procurement environment, and what the status of the program will be at that time. The assessments we make are based on the status of the program in the summer of 1990.

APPROACH

The project used case study analysis to develop, when appropriate, simple indicators of program stability that were common across past programs. This required that we look at weapon systems that had similar program attributes. Our choices were obvious: previous Air

Force aircraft MYPCs and the proposed B-2 procurement. The past procurements were the KC-10, the F-16, and the B-1B. Other Air Force MYPCs were for satellites and missiles that were unlike the aircraft procurements in terms of program costs, number of systems procured, or design uncertainty factors. General information about these aircraft MYPCs is shown in Table 1.

These cases provide some contrasts, and, although they include only three aircraft systems, they cover seven MYPCs. The KC-10 was developed from a well-established commercial craft. The F-16 had a long production history before its MYPC. An initial MYPC, denoted as F-16(I), was let in 1982, and a second F-16(II) was begun in 1986. Both aircraft used mature technologies, and their contracting experiences met performance, cost, and schedule expectations. The B-1B provides a closer match to the B-2, both being bombers under close scrutiny by the Congress. The B-1B procurement actually includes separate MYPCs with each of four primes, totaling four MYPCs. The B-1B procurement required substantial additional work after the MYPCs to meet performance specifications.

We developed the case studies from the literature and from interviews with legal experts, contract officers, engineers and managers at

Table 1

CASE STUDIES

Item	KC-10	F-16(I)	F-16(II)[a]	B-1B[b]	B-2
MYPC years	82–86	82–85	86–89	84–87	unknown
Quantity purchased pre-MYPC	16	650	NA	18	unknown
MYPC purchase	44	480	720	82	unknown
Total amount	60	1,130	3,000+	100	unknown
MYPC prime	McDonnell Douglas	General Dynamics	General Dynamics	Rockwell Boeing Eaton G.E.	Northrop
Other contractor	none	G.E.	G.E. P&W	none	G.E.

NOTES: G.E. is General Electric Corporation, and P&W is Pratt and Whitney.

[a]Over 2,729 are expected to be ordered by the Air Force. As of January 1989 1,429 were delivered. Foreign countries have bought about a thousand more.

[b]Quantities are for the airframe and offensive avionics. Defensive avionics had a previous buy of eight and an MYPC of 92 shipsets.

the system program office (SPO), prime contractors, and subcontractors. (For the KC-10, we relied heavily on written documents and interviews with the SPO, rather than interviews with the contractor.) Each procurement required the Air Force and the contractors to determine program maturity and remaining program risk. We specifically asked persons we interviewed how this determination was made and what indicators they used to assess program stability before commitment to MYP contracting.

We asked interviewees for indicators of program risk and their values for the programs of interest. Our purpose was not to quantify risk in these programs, an impossible feat, but to provide decisionmakers with indications of risk that they could use to open discussions about the risks and rewards of a potential MYPC. We asked for easily explained and understandable indicators that were available before the MYPC. We emphasized that they should have wide acceptance in the community, but that they should not require extensive data gathering and analytic methods. We preferred ones that were not subject to arcane discussions of exactitude.

Because of our approach, the indicators developed cannot be used in simplistic ways to arrive at remaining program instability. They are intended to be used with judgment to indicate areas of potential concern that must be addressed before MYP contracting.

Finally, we applied these indicators to the programs and drew lessons for the B-2 procurement.

OUTLINE

The remainder of this report documents the research and presents findings. Section II provides a legal history of MYP contracting for those unfamiliar with this contractual form. We use it to develop two main areas of congressional concern: (1) program stability, and (2) cost avoidance estimates. Section III addresses program stability by analyzing the indications of instability that existed on the previous Air Force aircraft programs at the time the decision to use an MYPC was made. Section IV examines the contractual arrangements used to reduce the remaining risk or to allocate it. Because remaining program risks are allocated by contractual devices, we used the contractual arrangements on previous MYPCs to develop further indicators of program stability. Section V addresses cost avoidance. In Sec. VI we apply the indicators to the B-2 procurement to show areas where uncertainty remains.

The report does not address the question of whether MYP contracting is a reasonable device for weapon system procurement from an economic point of view. In particular, we did not analyze the economic implications of the criteria Congress uses in approving MYPCs. However, as this might be of interest to some readers, we briefly address the issue in the appendix.

II. MULTIYEAR PROCUREMENT CONTRACTING

The "requirement" for a weapon system is established by a military service and validated by OSD. It is then translated into a production schedule that can cover more than one year if the quantities are large or the weapon system complex. Despite the need for several years of production, DoD normally acquires the system in a series of buys, using "annual" contracts because the U.S. Congress uses an annual budget cycle. Under annual contracting, a five-year production schedule would be managed under five sequential annual contracts, with yearly congressional authorizations and appropriations.[1] Congress reviews the procurements and appropriates funds accordingly. It makes tradeoffs among weapon systems and between weapons and other types of procurements and decides on an appropriation for that year. Such factors as the overall budget, trends in the amount of the defense budget, and the need for the program can all influence the congressional decision.[2]

Contractors perceive that business in this environment is inherently risky and make production decisions accordingly. Contractors are unlikely to invest in capital improvements or economic order quantity (EOQ) purchases, the cost of which cannot be recovered under a single annual contract.[3] Larger investments, which may reduce unit costs, impose a financial risk on the contractor. If Congress does not appropriate funds for out-year production, the contractor would be unable to recover its full investment.

MYP contracting is a means of providing program funding stability that encourages contractors to produce more efficiently and thereby reduce costs. Under MYP contracting, the Congress still appropriates

[1]Or a single contract with specified options for subsequent annual procurements.

[2]Much of the following discussion was borrowed from Edmund Dews and Michael Rich, *Multiyear Contracting for the Production of Defense Systems: A Primer*, The RAND Corporation, N-1804-AF, February 1982. We have updated the material to incorporate recent legislative actions.

[3]For example, the Air Force may intend to buy 100 craft over a five-year period at 20 per year. Under an annual contract, the prime would produce 20 per year and contract with its vendors for only enough shipsets to build 20 craft. Each year the process would begin again. Under an EOQ policy, the prime might order 100 shipsets from its vendors in a single year. Vendors would offer a lower unit cost for the 100 versus the 20 because of economies in their production, thereby reducing total procurement costs. Because the EOQ is ordered earlier in the program, it avoids the inflation-related expense of ordering smaller amounts over a five-year period.

funds on an annual basis and can cancel a program by not appropriating the out-year funds. However, with MYP contracting, through the authorization process the Congress commits to buying a production run with specified amounts for each year up to five years' worth of production. This commitment is backed by a contractual guarantee that the contractor will be paid a specified amount, called a cancellation amount, to cover out-year investments if the Congress does not approve out-year funding according to the agreed-upon schedule.[4]

The main benefit of MYP contracting is that it changes the funding environment of contractors so that they are more likely to make decisions that will reduce procurement costs.[5] The funding certainty generated by the production commitment enables contractors to use economic order quantities, lower overhead costs, and invest in new capital. These actions may also result in inflation avoidance. A single large economic order early in the program avoids the inflation cost of a series of annual orders of smaller quantities at inflated prices. In addition, MYPCs are fixed-price contracts; they cannot be cost based.[6]

Certain risks are associated with MYP contracting. The services might use MYP contracting to acquire weapon systems with a high probability of being canceled, reduced, or stretched out because of budget constraints, changes in the requirement, or technical difficulties. Commitment to an MYPC, if these events occurred, might prove costly. The government might be forced to pay large cancellation fees or acquire a weapon system at higher cost or reduced performance to avoid canceling the program outright and paying the fee. Further, the opportunity cost of such contracting would mean not procuring other needed systems. In addition, the fixed-price nature of the contract might prove detrimental to the contractor if costs should overrun because of technical problems. Finally, commitment to an MYPC reduces congressional and DoD flexibility in future budget years. The greater the early-on investment already made in the program, encouraged by the MYP contracting approach, the less likely Congress will be to terminate. The increased sunk cost

[4]The cancellation amount covers both outright cancellation of a program and stretchouts in the agreed-to production schedule in the out-years. However, the cancellation clause often specifies a dollar ceiling for any reimbursement should the program be canceled. This ceiling may not cover all the costs incurred by the contractor.

[5]Other means for reducing procurement costs exist; increased competition is a major one. Some argue that MYP contracting and competition used simultaneously could potentially reduce costs. However, the services have not used both means together. Competition of sources is carried on in the research and development phase of a procurement, while MYP contracting is employed after a source for production has been chosen. Thus, we do not focus on competition in this report, even though it may offer greater possibility for cost reduction than MYP contracting alone.

[6]It can be firm fixed-price or fixed-price incentive.

associated with an MYP approach compared with an annual approach makes Congress reluctant to cancel.

Thus, either party may not want to undertake an MYPC when the budget environment is uncertain or the budget is expected to decline. In these circumstances both parties might be cautious about committing funds to an MYPC if that later precludes their ability to reallocate funds in more appropriate directions. In essence, an MYPC increases the portion of the budget that DoD and Congress view as fixed. However, during a budget crisis the cost reductions associated with an MYPC might outweigh any reservations that decisionmakers have about flexibility.

Thus, the essence of a decision to use an MYP contracting involves weighing the potential cost avoidance produced by the production commitment against the probable dollar cost of cancellation given remaining program uncertainty. Even if DoD and Congress make MYP contracting commitments only to technically mature designs, they accept a risk that they will be forced to cancel because of their own actions involving the budget or actions taken by the nation or other nations that influence the national security. The annual contract lacks these risks but also has no cost reduction potential.[7]

To reduce procurement costs Congress authorized the services to use MYP contracting in 1963. Since then it has guided the use of MYP contracting to protect against the inherent risks. Congressional guidelines do not preclude any system from being considered for MYP contracting but require OSD and congressional oversight of higher cost programs.

Congress first increased its oversight of MYP contracting in 1975 when it placed a ceiling of $5 million on any cancellation amount and excluded recurring production costs. Under these restrictions, the services limited the use of MYP contracting to minor weapon systems.

In 1981, in an effort to encourage efficient production and lower costs, Congress passed legislation, now embodied in 10 USC 2306, to encourage the use of MYP contracting. The new law raised the cancellation ceiling to $100 million, allowed the inclusion of recurring production costs in the cancellation fee, and permitted advanced procurement of parts and economic lot purchases. Procurements with larger cancellation amounts require the authorizing agency to notify certain congressional committees. The law allows MYPCs to cover up to five years of production. The law ordered the Secretary of Defense to develop regulations covering the use of MYP contracting. Finally, the law encouraged MYP contracting between the prime contractor and its subcontractors but provided no incentives.

[7]The appendix examines this tradeoff in more depth.

While the legislation encouraged greater use of this contractual type, the law also limited its use to weapon systems that met specific criteria concerning program stability. The 1981 legislation mandated five criteria for MYP contracting for major weapon systems:

1. Stability of requirements—a firm minimum need in terms of production rate, procurement rate, and total quantities.
2. Stability of funding—a Department of Defense commitment to request funding throughout the contract period at the contract level required to avoid cancellation.
3. Stability of design—a stable design and no excessive technical risks.
4. Stability of cost estimates—confidence in realistic cost estimates.
5. Cost avoidance—reduced total costs under MYP contracting compared to an annual contract.

We use these criteria in the rest of the report to discuss the appropriateness of candidates for MYP contracting. We group the first four together under the term *program stability.* The Congress appears to be concerned that the candidate programs exhibit enough rate, design, funding, and cost stability so that cancellation will never become an option. We call the last *cost avoidance* and address it separately as the concern over potential benefits.

Since 1981, the Congress has consistently encouraged the use of MYP contracting but has added qualifications on its use through language contained in yearly authorizations.[8] This language has limited each contract to economic order quantities of $20 million per year and unfunded liabilities to $20 million *unless* certain congressional committees are notified; required all liability for economic order quantities to be funded; limited MYPCs to procurements of less than $500 million *unless* specifically approved by Congress; and required that a present value analysis be used to show real cost avoidance between annual and MYPC. The more recent acts have included several other important qualifications:[9]

- The current five-year defense plan must fully fund the support costs associated with the approved MYPCs.
- The approved MYPC provides for production at not less than minimum economic rates.

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[8]See for instance PL 98-473, section 8052; PL 99-190, section 8037; PL 99-500, section 9032; PL 100-180, section 108.

[9]PL 100-180, section 108; and PL 100-456, section 107.

- The MYPC must show a savings of 12 percent over that of an annual contract if it is a new procurement and a savings of 10 percent if it is a continuing procurement.

In addition, OSD and the services have promulgated regulations. Found in the Federal Acquisition Regulation (FAR) and the Air Force System Command Pamphlet 800-55, these regulations essentially follow the congressional language and establish requirements for an exhibit package to support an MYPC proposal. The exhibits provide information on the stability of the program and the sources of cost avoidance.

From FY 1982 to FY 1989, the Congress approved 57 major weapons systems for MYPCs with total obligational authority reductions estimated at $8,961 million.[10] Of these, 12 have been Air Force programs, including the F-16, the KC-10, the B-1B, several satellites, and a missile as shown in Table 2. Total cost reduction is estimated to be $4,449 million, a 14.3 percent reduction compared with the cost of using annual contracting.[11]

Table 2

AFSC MAJOR MYPCs APPROVED THROUGH FY 1988

Program	Quantity	Contract Value ($ million)	Estimated Percent Reduction Over Annual (%)
F-16	480	2,840	8.9
GPS	28	1,391	13.0
DSP I	4	1,031	5.7
KC-10	44	2,800	17.5
DMSP	4	245	19.2
B-1B	92	10,700	9.1
DSCS II	7	637	18.0
F-16 II	720	4,230	10.1
Titan IV	13	1,379	15.1
DSP II	5	2,432	27.8
F-16 III	600	3,973	9.6
DMSP	5	325	18.1

SOURCE: Major Gary Iverson, "Multiyear Contracting Briefing," Air Force Systems Command, 1988. Headquarters Air Force Systems Command/PKCP.

[10]Information obtained from Office of the Under Secretary of Defense for Acquisition, Assistant to the Secretary of Defense, Director Defense Systems Procurement Strategies.

[11]Major Gary Iverson, "Multiyear Contracting Briefing," Air Force Systems Command, 1988. Headquarters Air Force Systems Command/PKCP.

OSD and Congress have refused to approve many programs proposed for MYP contracting. Of 29 systems submitted by AF commands from 1982 to 1989, Congress nas approved only 12. Congress's reasons for rejection have varied, but two appear to dominate: The weapon system was technically immature, or the projected cost reduction was based completely on inflation avoidance. In addition, the services have been scolded for proposing MYPCs when Congress and DoD were likely to reduce the commitment in out-years.[12]

In summary, the Congress has encouraged the use of MYP contracting, while specifying its concerns about reduced flexibility and reduced control over procurement decisions once an MYPC is approved. The congressional language does not preclude the services from submitting perhaps less qualified candidates to Congress for approval. The law provides guidelines rather than absolute thresholds. For example, the law indicates that less stable programs or programs with fairly small cost reductions will receive additional congressional scrutiny. In short, the language guides the services as to which programs require congressional approval, which do not, and what risks the Congress is concerned about.

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[12]See for example House Armed Services Committee Reports HR 97-482, p. 65, 1982; and HR 98-107, 1983.

III. PROGRAM STABILITY

Congressional language describes four types of stability to be addressed in determining if MYP contracting should be used: requirements, funding, technical or design, and cost. Together they add up to what many people refer to as "program risk." When Congress requires the services to assess the stability of these factors, it really asks: How does it know that this program will run smoothly and not require cancellation or stretchout? What is the risk of cancellation and the implications for reduced congressional flexibility in dealing with budget issues?

In this section we explore the issue of stability. We first examine how contractors and the Air Force develop notions of program stability and then the specific indicators of stability found in past programs.

ASSESSING PROGRAM STABILITY

A major concern of Congress in assessing program stability must be the objectivity of the assessment. Does any model or method exist that can be used objectively to make the risk assessments required? How much confidence can Congress place in service and contractor assessment? To help answer this question, we reviewed the literature on risk assessments and asked both the relevant SPOs and contractors what kinds of methods and models they used to assess remaining program risk or instability.

Risk exists because the future remains unknown. Design uncertainty remains until the development test and evaluation (DT&E) program has been completed, usually not until well into the production stage. Some would argue that it remains until operational test and evaluation (OT&E) is completed, which would be further into the production cycle. Technical uncertainty leads to production cost uncertainties. In fact, some cost uncertainty will remain even after the DT&E program is completed because of unknowns regarding inflation, manufacturing processes, and operations and maintenance requirements. Requirements uncertainty remains throughout the program if the external environment is in flux.

Conceptually, we can think about the probability of stability using standard risk assessment language. The probability an event will occur is weighted by the cost associated with its occurrence to determine the risk associated with the event. Cost can include actual dollars spent

rectifying a problem, schedule slippage, poor performance of the weapon system, or reduced prestige in the defense community. Thus, assessments of probable stability should include the cost associated with the consequence and the probability of the consequence.

Past reviews of procurement procedures have recommended that formal risk assessment techniques be applied in the decisionmaking process.[1] By "formal" we mean that a well-documented and supported model be explicitly used to assess risk resulting in a written document that quantifies the risk associated with the program. However, formal risk assessments for complex weapon system programs are not straightforward for three major reasons.

First, the assessments are based on subjective judgements about both the probability of the event and the cost associated with it. Neither is a known quantity and both types of judgments must rely on expertise as much as solid data. Although the discipline of risk assessment has made great progress, it is still more an art than a science. Our review of currently used models and methods of risk assessment, largely geared toward technical and design risk, reveals that models still rely heavily on the use of subjective judgments. Models and methods may assign quantitative values to assessments, but these assessments are still based on judgments.

Second, identification of individual events is straightforward, but it is more difficult to assess the probability or cost associated with a complex series of events. For instance, quality control experts can measure the probability and cost of the failure of a single part by performing tests of mean time to failure. However, a complex weapon system such as an aircraft has thousands of interacting parts, and the proper functioning of some of the parts cannot be tested except by operating the system as a whole. Thus, despite the best subsystem testing programs, the performance level of the system is not proven until the entire craft is operated under all the conditions it will be likely to face. This phenomenon applies to any complex process, not just technical designs.

Third, the data requirements for proper risk assessments can be overwhelming. Data collection takes time and personnel, which translate into money. Oftentimes the data are simply not available.

All the above make it difficult to specify "program" risk. The assessment must take into account not just the risk associated with the performance of one component, but the risk associated with the performance of the entire system. Furthermore, "program" risk incorporates

[1]See Committee on Shuttle Criticality Review and Hazard Analysis Audit, *Post Challenger Evaluation of Space Shuttle Risk Assessment and Management*, National Academy Press, January 1988.

more than just technical factors. A proper assessment must consider the risk associated with factors such as the procurement strategy (e.g., whether a concurrent or nonconcurrent strategy is used), economic conditions such as inflation, the managerial capabilities of the SPO and the contractors, the technical capabilities of the contractor, and the financial standing of the contractors. Collecting and maintaining information on all of those factors would be costly and perhaps futile.

Nevertheless, despite the flaws of formal risk analysis, incorporating it into the decisionmaking process can be beneficial. At a minimum, a formal process forces decisionmakers to identify areas of risk and determine the means to address the risk. The value of the assessments lies not in the quantification of risk, but in the early detection of potential problems that might lead to undesirable outcomes.

We asked appropriate officers at the SPOs and at the prime contractors visited how they assessed program stability. They all answered in approximately the same terms:

- They were aware of commonly used formal models and methods of risk assessment and equally aware of their limitations, especially regarding their subjectivity.
- Contractors had established quality control offices and used engineering techniques, tests, and evaluation, and sophisticated models to identify technical problems where appropriate.
- Potential engineering, schedule, or cost problems were identified as soon as possible through frequent meetings of interfunctional project teams that represented all the major functional groups on the program. Contracts officers were included on these teams. Strategies to deal with potential problems were established in advance or as soon as the potential for the problem became evident.
- Program risk was assessed by these teams, *but* these teams did *not* use formal risk assessment models to determine program risk. No written documents with specific quantification of risk were produced.
- Instead, program risk was determined more informally by group consensus after discussion by members. Assessments were never quantified, with the possible exception of a high or low rating relative to other projects undertaken by the firm. These assessments were primarily for input to corporate strategic reviews.

We asked why the contractors did not use formal means for assessing program risk. The answer was straightforward. They did not need

to quantify risk to manage it. In fact, attempts to quantify it can easily mask important elements of risk. Recognizing the subjective and complex nature of assessments, they rely on their best experts, with many years of experience in the practical problems of program engineering and management, to identify and deal with risks. In addition, they use management techniques, such as the interfunctional teams, to ensure risks are addressed. They put their faith in their experienced personnel rather than necessarily oversimplified quantitative models that may misrepresent the true nature of the decisions to be made. Finally, remaining risks are managed through contractual clauses that allocate the risks between the government and the contractor. This is a key means of managing risk. Contracting officers are part of the management teams early on so that they can be aware of the risks involved and develop appropriate contract strategies.

The approach that we observed is consistent with approaches described in the business literature on decisionmaking. And it seems appropriate behavior given the complexity of the problem. Having confidence in the contractor's risk estimates means having confidence in its experts and its technical and managerial capability and believing that the incentives to misrepresent are not large.

Perhaps more important for our objectives, contract language will not quantify risk but will be used to identify and allocate risk. Contract language can be examined to indicate what risks concerned the parties to the contract when it was signed.

REQUIREMENTS STABILITY

Congress specified in 10 USC 2306 that the weapon system be stable:

> The minimum need for the property to be purchased is expected to remain substantially unchanged during the contract period in terms of production rate, procurement rate, and total quantities.

Numerous factors could change the national security requirement over the period of the contract. The services generally believe that establishing requirements is their responsibility, given guidance in the Strategic Integrated Operational Plan (SIOP). But political support from Congress, the president, and others is necessary to establish a production quantity and rate commitment. Therefore, indicators of requirements stability must address the political environment. Furthermore, the international security environment drives the threat analysis made by the services. International political alliances can

change the perceived threat and eventually the requirement for particular systems. The following rather nonspecific and diffuse indicators seem important:

- *Changes in the Threat Environment*—If the threat environment is in a state of flux, then the threat may change during the course of the program. A changing security environment means less requirement stability.
- *Service Requirement*—If the service has been inconsistent in its support of the requirements and has shown signs of changing the procurement quantity, the requirement is less stable.
- *OSD and Congressional Support*—Some programs elicit more high level oversight and review and are therefore susceptible to politically driven changes in the requirement. If the program production quantity and rate have been the subject of debate within this community, then the requirement is less stable.
- *Competing Technologies*—Some requirements can be met by other technologies at greatly reduced costs. Alternatively, expected technological breakthroughs might make requirements obsolete as new options become available to meet the threat. Where such opportunities exist, the requirement is less stable.

We asked program managers what perceptions they had of their program's requirements at the time of the commitment to an MYPC and reviewed the literature for support. Table 3 shows the general assessment of the requirements stability at the time of commitment to an MYPC.

The KC-10 and F-16 were expected to have very stable requirements over the course of their MYPCs. The Air Force firmly established the threat and mission requirement for the KC-10 and F-16. OSD and Congress strongly supported both programs, and the actions of our allies and enemies were expected to be stable during the acquisition of these aircraft.

The production rate and quantity of the two craft were more uncertain, but this did not influence the procurement very much. Minimum production rates and quantities were established for both that were high enough to merit MYP contracting consideration. These minimums were never questioned. Quantities over and above these amounts were possible, but higher amounts did not cause requirements instability as long as the minimums were guaranteed.

New technology was not an issue with either aircraft requirement. Although new technologies in fighter aircraft were expected, the F-16 was designed such that improvement could be modularly introduced.

Table 3

INDICATORS OF REQUIREMENTS AND FUNDING STABILITY

	KC-10	F-16 (I)	B-1B
Expected changes in threat	none	none	none
Expected changes in service requirement	none	none	none
Past OSD and congressional support	steady	steady	widely debated
Existing competing technology	none	none	ICBM
Expected competing technology	none	improved avionics	stealth
Expected defense budget trend	growth	growth	growth
Historical funding turbulence	minimal	minimal	yes before 1981, minimal after

All of the above expectations were met during the course of the MYPC.

The requirement for the B-1B, before its MYPC, was more problematic.[2] In general, the Air Force was committed to a manned bomber program, while others, including the White House and the Congress, contentiously debated the need for a bomber given other less costly alternatives. (Recall that the precursor to the B1-B was the B1-A, which Congress canceled at least in part because the requirement for the bomber had never been firmly established in its collective mind.) The bomber issue resurfaced in the 1980 presidential election. Discussions at the time questioned whether a new bomber was necessary, given the availability of less costly ICBMs. In addition, assuming a new bomber was required, some thought it should be postponed until emerging technologies could be incorporated. The need for the bomber was debated in Congress on and off for several years. However, the Air Force held fast to its immediate requirement for a new bomber, and

[2]An excellent discussion is contained in Nick Kotz, *Wild Blue Yonder*, Princeton University Press, Princeton, 1988.

after much political play Congress committed to buying the B-1B. Evolving threats from new technologies would be addressed by the advanced technology bomber (ATB) or by improvements to the B-1B.

Thus, the requirements stability of the three programs varied and for different reasons. Even though requirements stability for the B1-B was less than that for the KC-10 or F-16, Congress approved the MYPC. In short, requirements stability can be overlooked if the procurement suits a congressionally well-supported defense goal.

FUNDING STABILITY

Congress specified in 10 USC 2306 that the funding for the weapon system be stable:

> A reasonable expectation must exist that the Department of Defense will request funding throughout the contract period at the contract level required to avoid cancellation.

We used two indicators of funding stability: the expected budget environment and the past funding history.

Expected Defense Budget Trend—Air Force program and contractor personnel considered the defense budget trend as a key stability indicator. The budget environment can change the DoD commitment. Congress cannot change the threat assessment or the military requirement for a system, but Congress does change the defense budget, which in turn can cause the services to reevaluate their production rates and quantities. In periods of budget reduction, MYPC commitments may be risky. The service may be forced to cancel less important programs or to use stretchouts to accommodate the requirements of several important ones.[3] Under an MYPC, either can result in the award of cancellation fees. Thus, DoD must scrutinize trends in the size of the defense budget in the five-year period of the proposed MYPC to ensure that it will remain willing to back its program choice even if budget dollars become scarce. The greater the expectation of defense budget decline, the greater the instability of program funding.

Funding Turbulence—The General Accounting Office has used a different indicator of funding stability. It has looked at the program funding history to determine the level of commitment to a program from a congressional point of view. "A turbulent funding history for a

[3]For example, the current budget calls for the cancellation of 20 weapon systems to which DoD had previously committed. "Budget Request Eliminates 20 Weapons," *Defense News*, January 29, 1990, p. 1.

weapon system may suggest an unstable requirement or wavering support, making it inappropriate for multiyear procurement."[4]

Over the last decade, the budget environment for defense has changed. Late in the Carter administration, the defense budget began to grow as a result of a commitment to upgrade our forces. This was maintained during the early years of the Reagan administration when commitments to the KC-10, the F-16, and the B-1B were made. The outlook at the time of commitment to these aircraft was for increased defense spending.

Both the KC-10 and F-16 procurements had had stable funding histories. The B-1B program showed greater funding turbulence up to the commitment in 1981 to build the craft, especially if one considers the original B-1A procurement. This funding turbulence is associated with the bomber program because of the competing means of delivering strategic weapons to targets. Table 3 summarizes this discussion.

DESIGN STABILITY

It takes many years to develop and manufacture a state-of-the-art aircraft. When the services believe the threat is pressing enough, they have adopted a compressed schedule as a procurement strategy. This is often called concurrency.[5] Under this approach, the service allows the R&D or the test and evaluation stage to overlap with the production stage, incurring the costs of production equipment, long lead procurements, and production stage units before full proof of the design. A simple assessment is made: The real benefits of schedule compression are weighed against the probability and costs of technical problems. If technical problems are uncovered later, the aircraft may require redesign with resulting cost growth, schedule slippage, or reduced performance.

In the event of technical problems, the government may choose to delay the procurement of the system. Outright cancellation might be considered in the case of severe difficulties. A government decision to delay or cancel, of course, trips the MYPC cancellation clause and results in additional costs to the government. The other option in the

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[4]General Accounting Office, *Analysis of DoD's Fiscal Year 1985 Multiyear Procurement Candidates*, October 25, 1984, GAO/NSIAD-85-9, p. 5.

[5]Currently, there is a debate about how to define concurrency. All programs are at least somewhat concurrent. The full test and evaluation of the design is not completed before initial production commitments, especially for long lead items. Other programs have much greater concurrency, with testing taking place only after production aircraft have been produced.

event of difficulties is to accept a lower performance level, which may be equally costly in the long run.

To help avoid this type of occurrence, Congress mandated that MYP contracting be used only when the design for the system is stable and technical risks are not excessive. The literature and our interviews revealed a set of common indicators used by the design community to assess stability.[6] These indicators included but are not limited to the following.

Program Integration Responsibility—The choice is between a prime contractor and the government. Using the government as program integrator entails more risk than using a contractor because the government usually does not have the array of management techniques or engineering expertise available to a contractor.

Number of Primes—In most cases a single prime contractor oversees subcontractors, allowing for tight control over the design integration and final assembly. If two or more primes are teamed as associate contractors, the likelihood of problems with the technical integration of the craft increases.

Major New Technology Incorporated—The incorporation of major new technology not used on other systems raises the risk of technical difficulties. The more technical innovations incorporated (number of new technologies) or the more innovative a particular technology (innovativeness factor), the greater the risk is of technical problems. Past research has had difficulty quantifying a specific estimating relationship, but few deny that a relationship exists. Thus, we do not quantify the number or level of innovativeness of the technologies incorporated but list those areas of the system design that were substantially new and indicated a need for further understanding of the implications for design stability.

Development Flight Test Program Status Before the MYPC—The flight test program reveals technical flaws in the design of the aircraft. The more flight tests successfully completed at the time of commitment to an MYPC, the greater the likelihood that technical difficulties have been found and addressed. Few programs wait until full testing has occurred before production, but key tests should have been performed.[7]

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[6]Other indicators are possible and may be more quantitative. For example, Ron Hess of The RAND Corporation suggested the use of time tracks of the number of drawing releases per month or the number of engineering change proposals per month. If these indicate a steady decline, then the likelihood of technical problems is reduced. The consequence of an improbable technical problem, however, might be more substantial if many production craft must be retrofitted or redesigned.

[7]RAND colleague Giles Smith addresses just this issue in unpublished research undertaken as part of the cost reduction initiative.

Production Runs Completed or Number of Aircraft Completed—When asked by Congress to assess design stability of past MYPCs, the General Accounting Office used the number of production runs successfully completed before commitment. It states "a program should be judged mature and stable only after research and development and one or two production runs have been successfully completed."[8] Production runs used in this sense are taken to mean annual production contracts. Alternatively, if a full year of production has not taken place, the number of aircraft produced can be used as an indicator.

We compared past MYPCs using these indicators of potential risk. The values of these indicators varied for the MYPC studied, with the KC-10 and F-16 being considered more stable than the B-1B, as shown in Table 4.[9]

The KC-10

The KC-10 was developed from the commercial DC-10, which had been in service since 1970. The military application required a few changes from the commercial. Major modifications included the addition of an aerial refueling boom and a refueling receptacle, body bladder tanks, a refueling operator station, and military avionics equipment. All were based on proven designs and in total accounted for less than 8 percent of the cost of the aircraft. The test and evaluation program was completed six months after the first flight on July 12, 1980.

Table 4

INDICATORS OF DESIGN STABILITY

Indicator	KC-10	F-16 (I)	B-1B
System integration responsibility	prime	prime	government
Number of MYPC primes	1	1	4
New technology incorporated	none	flight control model change	avionics
Flight test status	complete	complete	incomplete
Number of aircraft produced at MYPC	14	500+	1

[8]General Accounting Office, *Analysis of DoD's Fiscal Year 1985 Multiyear Procurement Candidates*, October 25, 1984, GAO/NSIAD-85-9.

[9]The following information comes from interviews with prime contractors and SPO officials, multiyear exhibits, and internal program evaluation.

At the commitment to multiyear in December 1982, the flight test program was successfully completed and 14 production-line craft had been produced. In addition, the KC-10 had an annual production contract before the MYPC. The modifications to the aircraft were minimal enough to be done on the existing DC-10 production line. McDonnell Douglas acted as the single prime contractor and was responsible for program integration.

Assessments at the time show that developers believed the program had a mature design with little technical risk. The assessment proved correct. The procurement is known as a very successful example of the use of commercial aircraft for military purposes.

The F-16

Three prime contractors were involved: General Dynamics for the airframe and G.E. and Pratt and Whitney for the engines. The MYPC was with General Dynamics, which held responsibility for program integration.

The F-16 had been completely developed and tested, and over 500 aircraft had been acquired under annual contracts before the decision to use an MYPC for future procurements. Incremental improvements in the form of engineering change proposals were scheduled to be incorporated into the aircraft during the MYPCs covering 1982 to 1989, including a major design change from the F-16 A and B to the F-16 C and D in 1983 at Block 350. The model change in the middle of the first MYPC was of some concern to those who assessed the technical risk of the program. The concern was not with the technical risk of individual changes, but with the cumulative effect of the many changes incorporated in the model switch. Of some additional concern was a new flight control package incorporated under Block 40. This had thorough component testing before incorporation but had not been tested in the aircraft.

The SPO and prime contractor indicated that, although the aircraft has had many changes incorporated into it, the basic design has remained unchanged. The changes made have been modifications and modernizations rather than basic redesigns. The initial excellent design of the craft has permitted its slow evolution and modernization.

In initial MYPC submittals, the Air Force assessed the design as being stable, with design changes for the model switch being known in advance. The first MYPC was followed by a second in 1986. Congress has approved a third MYPC for the F-16.[10]

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[10]PL 100-456, section 107, September 29, 1988.

The B-1B

The B-1B contrasts with these two procurements in several ways. First, the government chose to use four MYPCs to procure the B-1B. Rockwell, Boeing, Eaton, and G.E. each had a separate MYPC. The government acted as the program integrator.

Although the B-1B is a modified B-1A, a new state-of-the-art defensive avionics suite was incorporated. The other major changes were the expansion of the aircraft and the addition of an offensive avionics suite. These latter two changes were based on known designs and technologies.

The design was not fully tested before the MYPCs. The R&D contract was signed on the same day as the low rate production contract. Only a single aircraft was produced under annual contracting before the MYPC commitments. The flight test program had not been completed. However, two B-1As had been retrofitted and flown before the MYPC commitments. At the time, the Air Force assessed the program as having low technical risk, despite the new, untested avionics, four primes, and limited flight tests.

The B-1B, however, had more technical difficulties than predicted. Hindsight shows that the offensive avionics and the engines were technically mature. The swing wing and fuel tanks on the airframe have had some difficulties, but the real technical problems came from the defensive avionics built by Eaton. These difficulties have added to the cost of the aircraft after the MYPCs and delayed its effective combat capability. The Air Force estimated the cost of fixing the defensive avionics to be about $1 billion. An additional $0.9 billion in capability improvements is planned.[11]

These problems with the technical performance of the B-1B have caused the Congress to increase its scrutiny of the program. Authorization language requires the Air Force to submit test plans for the defensive avionics to Congress, obtain an independent assessment of its capabilities, and submit quarterly reports and new cost estimates of program improvements.[12]

Critics have questioned the validity of the Air Force assessment of technical risk for the B1-B program. Our purpose is not to examine that decision but to point out the repercussions of technical risk under MYP contracting and to show Congress's reaction. SPO officials we interviewed stated that a major lesson learned from the B1-B

[11]"Air Force Plans $1 Billion Fix For B-1B Bomber's Defensive Avionics," *Defense Week*, March 13, 1989. "Air Force Wants $1.9 Billion Through FY 94 to Fix, Improve B-1B," *Aerospace Daily*, May 3, 1989, p. 185.

[12]PL 100-180, sections 242 and 243, and PL 100-456, section 231.

procurement is that extensive concurrency in a program is risky when new technology is involved.[13]

Discussions with officials at the B-1B SPO indicate that technical problems were exacerbated by the combination of different primes, no one of them clearly responsible for program outcomes. This strategy resulted in poor communications between the primes, difficulties in fixing problems when they arose, and general lack of technical coordination. Officials stated they would never use the strategy again.

The assessment of the efficacy of the MYPCs for the B-1B is problematic. SPO and contractor officials perceived that the MYPCs with Rockwell, Boeing, and G.E. were executed smoothly. The SPO gave the MYPC with Eaton lower marks.[14] In hindsight, the SPO now sees that too many technical problems remained. However, even if three of the MYPCs exhibited the expected stability, the complete MYP contracting strategy for the B-1B did not.

COST STABILITY

In an MYP environment with evident cost growth, the government may be faced with a choice of weighing expected cost growth against cancellation fees in deciding whether to continue the program. The Congress specified that estimates of program cost be realistic, which has been taken to mean that estimates be based on firm or certain data, with resulting reliability. For this reason, the Air Force bases its cost avoidance estimates on two separate bids by the prime, implying contractor commitment to the estimates.[15]

The literature and interviews at the SPO and with contractors provide the basis for developing some indicators for cost estimate reliability.

Requirements, Funding, and Design Instability

The most obvious predictors for potential for cost growth are remaining requirements, funding, and design instability.[16] Correcting unforeseen technical problems always results in increased costs,

[13]This lesson has been "learned" several times and just as often forgotten.

[14]We have not discussed this with Eaton.

[15]The development of these bids is discussed in more detail in Sec. V.

[16]Research has been done on trying to predict cost growth or schedule slippage from technical factors such as amount of new technology incorporated, where in the system the new technology is incorporated, etc. All of the work amounts to saying that where technical risk remains, the potential for cost growth is higher than when technical risk is not evident.

although the budget may not overrun if a "fudge" factor for this contingency has been included. Changes in requirements or funding produce changes in production rates or quantities that usually increase unit costs. Although total program costs will not necessarily escalate, the increased unit costs mean fewer aircraft can be bought at the same price as before. Remaining instability in these areas means the cost estimates might be unreliable.

Proven Manufacturing Process Reliability

Cost growth can also come from the technical uncertainty of the manufacturing process. New and unproven processes that do not perform as expected may result in escalating production costs. Two important indicators of cost stability are the number of technical advances incorporated into the manufacturing process, and the production experience upon which the estimates are based. The latter means that the cost estimates would be more reliable if they were based on experience from several production level aircraft built at the production rate that will be used under the MYPC.

The cost effect of changes to the manufacturing process is problematic. The effect of production-line changes due to technical or rate revisions may be lessened if capital investments in the affected portion of the manufacturing process are not complete. If changes must be made, both the original and the new investment costs are incurred. If full investment had not yet occurred, there would be less cost associated with changing. This does not argue, however, for not investing in full production capital until design stability. Waiting on capital investments till the design is proved may impose other delay-associated costs. Less cost reliability may result if cost estimates cannot be based on actual production experience.

The reliability of estimates will vary depending upon what portion of production experience or technical performance remains uncertain. If the uncertainty involves only a minor subcomponent and this item will not affect other costs, then the reliability of the program estimates will not be affected. Only when the uncertainty affects large portions of the cost structure is it important.

Level of Expected Inflation

One source of uncertainty that can affect the entire cost structure of the program is inflation. Empirically, our ability to forecast the annual rate of inflation has fallen as the observed inflation rate has risen. Hence, procurements undertaken in years of high inflation will have

more uncertainty associated with the cost estimates than ones made in more stable economic times. The common approach to this problem is to incorporate inflation considerations into the cost data.

We used the above indicators to compare the cost certainty of the past MYPCs as shown in Table 5. In general, the cost estimates of the KC-10 and the F-16 were based on more reliable information, actual production experience, than that of the B-1B. The KC-10 and the F-16 both had proven designs and proven manufacturing processes with no new technologies. Both used existing production lines to produce the MYPC aircraft. The requirements were stable, so the production rates were not expected to vary. However, the price outlook at the time was for fairly high rates of inflation creating uncertainty in otherwise established costs.

In contrast, the B-1B had some technical uncertainty associated with the defensive avionics and had produced only a single aircraft at the time of commitment. Thus, the cost estimates were based on more limited experience. Nevertheless, the technical uncertainty was associated primarily with the avionics package, reducing the effect of uncertainty on total program cost estimates. Rockwell, Boeing, and G.E. based their estimates on past production experience, especially from the B-1A production line. The economic climate for the B-1B was one of reduced inflation; it was not expected to greatly affect the cost estimates.

Table 5

INDICATORS OF COST ESTIMATE CERTAINTY

Indicator	KC-10	F-16 (I)	B-1B
Requirements assessment	stable	stable	stable
Funding assessment	stable	stable	stable
Technical assessment	stable	stable	unstable
Major new manufacturing processes	none	none	none
Number of aircraft produced	14	500+	1
Inflation	high	high	low

The reliability of the cost data for the B-1B may have been more questionable than that of the KC-10 and the F-16, but the price of the B-1B was exact. It was procured under a price ceiling set by Congress for $20.5 billion in FY 1981 dollars. The price cap could not be exceeded. Over the long run the cost certainty imposed by this cap proved to be illusory. Subsequent budgets contain monies to bring the capability of the craft up to expected performance levels.[17]

SUMMARY

Our review of formal risk assessment techniques used by contractors shows that they rely less on formal quantification than on managing risk identified through management processes. Contractual agreements are one means to allocate remaining program risk.

The analysis above demonstrates that the indicators we used to assess stability in procurements, available before the MYPC commitment, could be used to support congressionally mandated exhibits on requirements, funding, design, and cost stability. Indicators for the KC-10 and F-16 procurements show more stability than indicators for the B-1B. B-1B assessments at the time, however, did not flag these indications of remaining instability.

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[17]"Air Force Plans $1 Billion Fix for B-1B Bomber's Defensive Avionics," *Defense Week*, March 13, 1989. "Air Force Wants $1.9 Billion Through FY 94 to Fix, Improve B-1B," *Aerospace Daily*, May 3, 1989, p. 185.

IV. USE OF CONTRACTS TO ADDRESS UNCERTAINTY

The previous section addressed the question of how uncertainty was assessed on previous MYP programs and what those assessments were. We developed a set of indicators to reflect these uncertainties. This section reviews what contract terms were used in previous MYPCs and uses this information to identify contractual terms that, when proposed for an MYPC, can serve as indicators of remaining instability.[1]

CONTRACTUAL MEANS FOR ALLOCATING RISK

Contractual language does not remove risk from a program. Instead it allocates the remaining risk between the parties to the contract and provides incentives to reduce risk.[2] The following general principles can be applied to develop contractual language to handle different contingencies:

- All else equal, the contract should reduce contracting risk per se by discouraging both parties from reopening the contract in unexpected ways. For example, well-crafted economic price adjustment clauses provide a predictable and equitable way for both parties to react to inflation risk.
- All else equal, the less risk-averse party should bear more contract risk. In terms of a government procurement contract, the government is generally held to be less risk-averse than the contractor. The government portfolio of investments is broader and more diversified than that of any privately held company.

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[1]In this section we use language familiar to the contracts officer, but perhaps unfamiliar to others. We do not provide extensive background information; we assume the audience for this document understands the basic terms of contracts. For those unfamiliar with risk allocation and contracts language, see Headquarters Navy Material Command, *Defense Fundamentals of Incentive Contracting*, Department of Defense; Frederick Moore, *Military Procurement and Contracting: An Economic Analysis*, The RAND Corporation, RM-2948-PR, June 1962; Ralph Miller, *A Method for Selecting Contract Cost Incentives*, The RAND Corporation, RM-5122-PR, March 1967.

[2]The choice of contractual vehicle, which broadly speaking can be thought of as a choice of contractual language, can affect the total level of risk in a procurement. The appendix discusses this point in the context of choosing between an annual contract and an MYPC.

- All else equal, the party to the contract with more control over a risk should bear that risk. In practical terms, this means that the contractor should bear the risk associated with its manufacturing and production management, but the government should bear the risk introduced by its own actions.

Three categories of contract terms address risk by allocating it between parties or by offering incentives to reduce it.

- *Contract type* defines the relationship between cost and price. Examples are cost-based or fixed-priced contracts.
- *Cost and price arrangements* define profit parameters and cost reduction incentives.
- *Risk allocation clauses* allocate other risks that affect cost and price. These include warranty, indemnification, termination, cancellation, and engineering change proposal clauses.

Contract Type

The contract type determines which of the parties to the contract bears the general risk associated with remaining cost uncertainties. Two general types of contracts exist: cost-based and fixed-price. In the extreme, cost-based contracts require the government to reimburse the contractor for all costs associated with a program. The government, not the contractor, undertakes the cost risk. Cost-based contracts are used on programs where cost uncertainty remains high. It is an open-ended contract; the contractor provides its best efforts until the government determines that a suitable product, given the budget, has been produced.

At the other extreme, firm fixed-price contracts require the government to pay an agreed-upon price for services specified. It is a completion form of contract—the contractor is required to perform a specified service regardless of the final cost outcome. The price is intended to cover both costs and a fee for profit. If costs exceed the price, the contractor must cover them with other sources of funds; thus the contractor bears the risks. Firm fixed-price contracts are generally used when the program risk is low.

Both fixed-price and cost-based contracts can be modified into incentive contracts, known as cost-based incentive (CBI) or fixed-price incentive (FPI) contracts. The basic objective of incentive contracting is for the government to reward the contractor for cost underruns and penalize the contractor for cost overruns. For example, in an FPI contract, a target cost and a target profit are established. When added together they equal a target price. The target profit is increased by a

formula for actual cost outcomes less than the target cost and decreased when the final cost exceeds the target cost. The formula defines the "share line," which we discuss below in more detail.[3] In no circumstances will the government pay more than an established ceiling price. In a CBI contract, similar incentives for cost reduction are set up using a target cost and a target fee. The fee earned is higher than target fee if actual cost results are lower than target costs. The fee earned is lower than the target fee if actual cost results are higher than target costs. No ceiling price exists, so the government commitment is unbounded.

In general, the contract type used on a program advances from cost-based contracts during the R&D stage to fixed-price contracts during full-scale production. Interim stages, such as low rate initial production, may be under some sort of incentive contract that shares risk between parties. The reason for the progression of contract type is simple. Uncertainty is greatest in the early part of a program and diminishes as information on the design and cost accumulate and improve. The government is considered to be better able to bear risk; therefore, cost-based contracts are used for research and development. As risk diminishes, the contract type changes to provide incentives to reduce costs and to force contractors to bear more of the remaining, but reduced, risk. Further, residual risk under a production contract is increasingly influenced by the contractor's behavior as production proceeds.[4]

Following a pattern of changing contract form over the program allows for a further means to allocate risk. At each stage in a procurement, the parties can review new cost and technical data to determine

[3]Share lines refer to the agreement on who shall cover cost overruns and underruns in incentive contracts. For example, the parties may agree that in case of an overrun the government would bear 60 percent of the risk and the contractor 40 percent. The share line would be 60/40. For every dollar of cost overrun, the government would pay 60 cents and the contractor would pay 40 cents. In an FPI contract, once the ceiling price is hit the contractor would bear all overrun costs. Obviously the share line can be manipulated to provide incentives for cost control. A overrun share line of 40/60 would give the contractor more incentive to reduce costs than a share line of 60/40. An underrun share line of 10/90 would provide the contractor with greater inducement to control costs. In reality, the share line may shift over the program life to put the contractor more at risk. Government negotiators whom we interviewed believed that any fixed-price incentive contract with an overrun share line of 60/40 should be converted into a firm fixed-price contract.

[4]In recent years the DoD encouraged the use of fixed-price contracts for the R&D stage of programs. Many of the contractors involved were unable to accurately predict costs and are now suffering the consequences. See "End of Fixed-Price Development Is Too Late To Help Some Primes," *Aerospace Daily*, July 26, 1989, p. 146; "Fixed-Price Development Growing Despite DoD Pledges," *Aerospace Daily*, August 17, 1989, p. 292; "Industry, Government Said To Share Blame for Fixed-Price Problem," *Aerospace Daily*, August 18, 1989, p. 300.

the remaining risk. The new contract can then allocate the remaining risk accordingly. Procurement strategies with several contractual stages allow for frequent risk-review points. Both parties benefit because neither will be held to a long-term contract that causes financial distress.

Contractual Arrangements

Contractual arrangements define the profit parameters and in so doing create risk reduction strategies. Arrangements include agreements on profit fees in cost-based contracts; and target costs, ceilings, and share lines on incentive contracts.

These arrangements can indicate the level of risk associated with a procurement. For instance, the greater the risk borne by the contractor, the greater the profit rate allowed. The government uses standard weighted guidelines to determine this so that a fixed-price incentive contract would have a profit rate of 2 percent below a fixed-price contract. The ceiling on FPI contracts also varies with risk. The riskier the program, the greater the percent difference between the target costs and the target ceiling. Contract officers we talked with stated that ceilings range up to 135 percent of target costs for the most risky programs.

A further risk allocation feature that can be added to an incentive contract is a successive target agreement (FPI(S)). When costs are uncertain, the parties can agree to finalize the target cost of the contract at a prespecified future time when they expect more certain cost information. This is in contrast to specifying the target cost of the contract when it is signed (known as fixed target or FPI(F)).

Special Clauses

More specific risks can be addressed through special provisions or special clauses appearing in Section H of a contract. Five are of particular interest in MYP contracting.

- *Economic Price Adjustment* (EPA) clauses establish the index used to adjust input prices for determining the cost base of the contract. The more inflationary the times, the more important these clauses become.
- *Termination* clauses allow the contractor to recover incurred production costs for the current contract year. The government can initiate termination for cause at any time during a contract. Termination clauses are found in all contracts.

- *Cancellation* clauses allow the contractor to recover out-year production costs that have been incurred in the current year. They are found only in MYPCs and usually cover the unrecovered cost of the EOQ. They only apply in the event that Congress does not appropriate funds for the out-years of a program and can only be initiated at the beginning of a contract year. If an MYPC is canceled, then the termination clause covers the incurred cost for current year production and the cancellation clause covers the incurred cost for out-year production. Together they should cover the contractor's total incurred production costs.
- *Indemnification* clauses allow the contractor to recover capital, facilities, and idle capacity (nonproduction) costs when triggered by specific events, such as termination or cancellation.[5] In a multiyear contract, a capitalization schedule for payment is negotiated in advance that determines how much the government must pay the contractor in case indemnification is triggered. This coverage encourages the contractor to invest in cost-reducing capital and facilities improvements, the costs of which cannot be recovered under a single year of production. If a contract is ended and the government pays the indemnification fees, the contractor turns over the property indemnified to the government. Precontractual negotiations determine what capital investments are included. The contractor chooses which items it would sell and include in the clause and which items it would keep and not include in the clause. This type of coverage is separate from any monetary incentives the government offers for technical or production improvements.
- *Engineering change proposals* (ECPs) allow the government to change the technical specifications of the weapon system as appropriate. ECP clauses contain language that allows for the renegotiation of the contract cost base in this event. It protects the contractor from cost growth imposed because of government actions to improve the system.
- *Warranties* define who bears the risk of poor performance or operation. The more uncertain the technical performance at the time of the contract, the more limited the warranty will be, so that the government bears the risk of nonperformance and the costs of improving performance through ECP clauses. Standard warranty clauses cover material and workmanship,

[5]These clauses have several different titles. Examples include Idle Facilities/Idle Capacity or Capital Investment Incentives.

design conformance, and minimal performance standards. Contractors limit their liability by specified dollar ceilings on their warranties, delayed specification of the performance measures, reduced time coverage, or refusing to warrant specific technical performances.

Implications for Multiyear Procurement Contracts

At its simplest, an MYPC is a fixed-price contract with cancellation clauses. Beyond that, every MYPC we examined was different. Differences in type, arrangements, and clauses reflect the special circumstances of each procurement. In their negotiating strategies, the government and contractors make tradeoffs between these terms in an attempt to reduce total risk or reduce the effect of the most burdensome risk. For example, a contractor that is very uncertain about the technical performance of the design may be willing to lower its profit rate if the government agrees to reduce its warranty requirements. Contractors make implicit and sometimes explicit calculations as to which risks are greatest and how to cover them.

Taken together, the characteristics of a contract provide a detailed image of the perceived risk inherent in a program at the time the contract was let. The contingencies addressed by these characteristics indicate where the parties to the contract thought risks remained. That is, we can use the terms of these contracts as indicators of remaining risk. The more the type, arrangements, and clauses allocate the risk to the government, the stronger the indication of remaining program risk that the contractor would not bear.

Contracting in an environment in which the contractual terms will hold for several years increases the importance of the risk allocation terms of the contracts. Under annual contracting, these terms might be renegotiated each year as problems arise, reallocating the risk burden as appropriate.[6] Under MYP contracting with a several-year commitment, this renegotiation will not occur. Faced with uncertainty, a rational contractor would logically prefer the following terms to protect its interest in an MYP contracting environment.

- Use of an FPI contract with a high percentage difference between the target cost and the ceiling when technical or cost uncertainty exists.

[6]Annual contracts often have terms that carry over into subsequent contracts. For instance, indemnification clauses carry over until the investment is depreciated according to the agreed upon schedule.

- A share line that imposed the least cost overrun risk on it, say 90/10 rather than 60/40, when technical or cost uncertainty exists.
- Warranty clauses that limit its responsibility and ECP clauses that allow for renegotiation if the government changes the system design when the design is unstable and performance remains unknown.
- Extensive and specific EPA clauses when the economic outlook is uncertain.[7]
- Generous indemnification, cancellation, and termination clauses when requirements are unstable and the budget is tightening.

CONTRACTUAL TERMS OF PAST MYPCs

We reviewed the relevant contracts with SPO officers and contractors to determine why certain clauses were used and how the clauses protected them. The various contractual terms indicate that the KC-10 and the F-16 were treated as more stable programs than the B-1B. The contractual terms show the KC-10 and F-16 contractors willing to bear more contractual risks than the B-1B contractors, excepting the engine contract. Thus, the indicators provided by contractual terms are consistent with the indicators discussed in Sec. III.

Contractual Type and Progression

The progression pattern of the contracts shows interesting contrasts, with implications about assessments of risk made at the time. These progressions are shown in Table 6.

First, the progression from cost-based to fixed-price contracts varies in each of the procurements. The KC-10 and F-16 procurements followed the normal progression pattern of contract type. They both used cost-based contracts in the R&D stage and progressed to firm fixed-price contracts (FFP). The B-1B began with fixed-price initial full-scale development contracts (FSD) for limited design revisions of the B-1A and testing. By full-scale development, the contracts had progressed to fixed-price incentive. However, by full-rate production, three of the B-1B primes had not progressed to the firm fixed-price contract. Only the engine contract used a FFP contract.

Second, the F-16 and the B-1B used a fixed target cost with their FPI contracts. None of these contracts used successive pricing, indicating that costs were certain enough to commit to a target cost.

[7]10 USC 2306 and the regulations encourage the use of EPA clauses in all MYPCs.

Table 6

CONTRACT PROGRESSION TO MULTIYEAR PROCUREMENT

			B1-B			
Contract Type	KC-10	F-16	Rockwell	Boeing	Eaton	G.E.
FSD	Cost	Cost	FPI(F)	FPI(F)	FPI(F)	FPI(F)
LRIP	None	Unknown	FPI(F)	FPI(F)	FPI(F)	FPI(F)
Annual production	FFP	FPI(F)	None	None	None	None
MYPC(I)	FFP	FPI(F)	FPI(F)	FPI(F)	FPI(F)	FFP
MYPC(II)	NA	FP	NA	NA	NA	NA

NA = Not applicable.

Third, the KC-10 and the F-16 progressed directly from full-scale development to production contracts. The B-1B had interim contracts for low-rate production. This renegotiation of contracts before full-rate production allows the incorporation of more certain information before any multiyear commitment.

Fourth, the KC-10 and the F-16 had full production contracts before the MYPC. The B-1B transitioned from a single Low Rate Initial Production to the MYPC based on limited production data.

Contractual Arrangements

The profit arrangements and cost control incentives for the MYPCs studied also differ between the contracts as shown in Table 7.

First, the KC-10 and F-16 contracts indicate that remaining risk was low at the time of the MYPCs. McDonnell Douglas was willing to accept a straightforward fixed-price contract. General Dynamics initially accepted a fixed-price incentive and then a fixed-price contract. The MYPC(I) FPI contract, however, had a low percent difference between the target cost and ceiling and a share line that imposed 40 percent of cost overruns on General Dynamics. Both indicate that General Dynamics perceived little remaining cost risk at the time of the multiyear. This interpretation was borne out in our discussions with them.

In contrast, the arrangements on the B-1B indicate more risk remained in the program. The cost and ceiling differential is greater than that for the F-16 and the share line imposes much less risk on the B-1B contractors than the share line for the F-16.

Table 7

MULTIYEAR PROCUREMENT CONTRACTUAL ARRANGEMENTS

			B1-B			
Contract Type	KC-10	F-16	Rockwell	Boeing	Eaton	G.E.
MYPC(I)						
Type	FP	FPI(F)	FPI(F)	FPI(F)	FPI(F)	FFP
Ceiling percent	NA	123	135	125	134	NA
Share line						
Over	NA	60/40	80/20	75/25	80/20	NA
Under	NA	60/40	50/50	50/50	80/20	NA
Negotiated profit (percent)	NA	14.5	14.2	13.5	14.0	NA
MYPC(II)						
Type	NA	FP	NA	NA	NA	NA
Negotiated profit (percent)	NA	15.0	NA	NA	NA	NA

NA = Not applicable.

Special Clauses

The special clauses incorporated into the case study contracts also indicate some areas of different assessments of remaining risk by the parties involved. However, clauses were similar in a number of areas.

First, each of the contracts have EPA clauses to address the likelihood of inflation over the life of the contract. None is standard. Each uses different indexes and factors, depending on the type of product produced. The experiences of the 1970s have made these important to every contract.[8] In particular, the KC-10 contract had very elaborate EPA clauses compared with the other procurements, demonstrating greater concern with the risk of inflation.

Second, cancellation and termination clauses on all the contracts appear to be similar and cover the advanced buy items such as long lead and EOQ purchases. The possible exception was the cancellation clause for the B-1B airframe, which was very detailed regarding what was or was not covered under a cancellation. Others had simple schedules of payments. The amounts covered under the different cancellation clauses varied substantially, but this is to be expected because of the different costs of items produced.

[8]Discussions with SPO officials indicate that some of these clauses are so complex that no one understands their effects. They are therefore the cause of many disputes after contracts are signed.

Third, all had very standard ECP clauses that protected the contractor against cost changes due to government prescribed technical design changes.

Incorporation of the EPA, cancellation, and ECP clauses in all the contracts indicates that risks remained in those areas. The similarity of the clauses, except for the EPA, indicates that standard language adequately protected the contractors against those risks. Important differences occurred in other clauses, pointing to important differences in perceived risks. Table 8 summarizes these.

A major difference is that the KC-10 and F-16 contracts contain no indemnification clauses, while the B-1B airframe MYPC had strong indemnification clauses to protect the contractor. The explanation is simple.

The KC-10 and the F-16 MYPCs did not occur until the production lines had been established and running for several years. New design specifications caused few changes in the production line process. Thus, investments in production were recovered under previous contracts. Furthermore, the facilities for the F-16 production were largely government owned, requiring no indemnification.

In contrast, the B-1B airframe contract (Rockwell) had clauses covering substantial portions of its capital and facilities investments. Discussions with the contractor indicate it made large capital investments for production efficiency but was hesitant to invest without protection against program cancellation. The Air Force recognized that these investments would lower unit costs and partly indemnified the contractor against cancellation and stretchouts. Some risk remained with the contractor, because the coverage was partial for two reasons. First, the government would not indemnify the entire investment, preferring to

Table 8

MULTIYEAR PROCUREMENT CONTRACT CLAUSE DIFFERENCES

			B1-B			
Difference	KC-10	F-16	Rockwell	Boeing	Eaton	G.E.
Indemnification	No	No	Yes	No	No	No
Warranty time	60 months 5,000 hours	180 days	6 months	6 months	6 months	7 years
$ Cap	No	No	Yes	No	Yes	Yes
Delayed specification	No	No	Yes	Yes	No	No

impose some risk burden on the contractor. Second, the contractor chose to keep certain investments free of an indemnification clause so as to retain ownership in case of cancellation. The contractor included only those items for indemnification that it could not hope to use in its other production programs. The indemnification clauses were found in the FSD contract and carried over into subsequent contracts.

Warranty coverage also differed between the contracts. In general, the KC-10, F-16, and engine contracts used standard clauses and provided the most coverage, while the B-1B nonengine contracts provided the least coverage and used unique clauses to expressly define liabilities.

Each contractor warranted material and workmanship and design specification conformance. All of the contracts used time thresholds to limit their liability. For example, General Dynamics warranted materials and workmanship for 180 days after delivery, while McDonnell Douglas warranted the design for 24 months and the materials and workmanship for 60 months. The B-1B nonengine contracts had warranties of six months after delivery, and the engine contract had a warranty of seven years.

The B-1B contractors limited their liability further through use of additional clauses. At the time of the B-1B MYPCs, some design and performance characteristics could not be fully specified, because the flight test program was not complete. After completion of the tests, the final specifications were determined for purposes of the warranty. Therefore, Rockwell and Boeing agreed to warrant design and performance specifications that were determined after the tests and after the signing of the contract. All subsequent aircraft produced would have to meet those specifications. This limited their liability because they agreed only to cover the performance characteristics actually achieved. They did not cover expected but unproven performance.

The Rockwell and Eaton contracts specify additional dollar limits to the contractor's liability. Costs associated with the fixing of design deficiences were to be included in the target cost determination up to a ceiling. Any cost over that ceiling would have to be reimbursed by the government. These limits did not apply to material and workmanship.

Discussions with SPO and contract representatives indicate that these limits were required for two reasons. First, program concurrency resulted in unknown performance attributes. Second, Rockwell was not willing to warrant the performance of the total aircraft because the other primes were not under contract to it. It could not, therefore, impose any warranty responsibility on the other contractors. The limits on warranties were acceptable to both the government and the contractors under the circumstances. The contractors could not afford the

risk of warranting performance without greatly increasing the cost of the contracts. The government could not afford those costs.

SUBCONTRACTS FOR THE MULTIYEARS

Congress was concerned that the full cost avoidance possibilities of MYP contracting could not be achieved unless prime contractors used MYP contracting with their subcontractors. Although this was not mandated, congressional language encouraged it. The question then arises, what subcontractual arrangements were used on these MYPCs? To determine this, we asked prime contractors what arrangements were used, referred to an excellent study done by the General Accounting Office, and contacted several subcontractors.[9]

Our investigation showed a fairly consistent set of replies for the F-16 and B-1B primes and subcontractors.[10] These prime contractors tended to use firm fixed-price contracts, usually for a single year, to procure supplies from a subcontractor. The subcontracts did not have EPA clauses unless the contract was for more than a single year. Being annual contracts, they had no indemnification or cancellation clauses. They did, however, contain standard termination clauses covering the subcontractors' incurred production costs. Standard warranties of material and workmanship and performance and design specifications were provided. In some cases, depending on the delivery schedule and how long delivered items would be stored unused, warranties had time limits.

In sum, we found that information about subcontracts did not yield useful insight into risk indicators.

SUMMARY

Our review of contracts and interviews with contractors and the SPO show that, although these groups do not formally assess program risk, they do informally analyze it. They actively identify where risk remains and use contractual means to allocate it appropriately.

Taken together, the characteristics of a contract provide a detailed image of the perceived risk inherent in a program at the time the contract was let. The contingencies addressed by these characteristics

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[9]General Accounting Office, *Procurement: Multiyear Contracting and Its Impact on Investment Decisions*, May 1988, GAO/NSIAD-88-125.

[10]The exception was General Electric, which made extensive use of multiyear terms in its subcontracts for the B-1B procurement.

indicate where the parties to the contract thought risks remained. The more the type, arrangements, and clauses allocate the risk to the government, the stronger the indication that remaining program risk was a concern. For an MYPC commitment this means special emphasis on incentive contracting, the ceiling percent, share line, and EPA, cancellation, indemnification, and warranty clauses. Information about these contractual terms can provide the basis for useful indicators of remaining program instability at the time MYP contracting is considered.

Analysis of past MYPCs shows that the major risks perceived for the KC-10 and F-16 contracts were related to inflation and cancellation. The B-1B contract shows similar concerns about inflation and cancellation but required more coverage, including indemnification of capital and facilities to protect against changes in commitment. In addition, design maturity remained questionable for the B-1B program, resulting in limited warranty liability.

In each case, uncertainties evident at the time of commitment to multiyear were handled by specific terms of the contract. The KC-10 and F-16 contracts showed the government bearing less contractual risk than in the B-1B contract.

V. COST REDUCTIONS ESTIMATED FOR PAST MYP PROPOSALS

The primary benefit of using MYP contracting is that, by creating a sense of predictability, it allows the prime contractor and its subcontractors to produce more efficiently and thereby reduce the costs of providing weapon systems. Proposed cost reductions are critical to the approval of an MYPC. Unless an exception is specifically approved by Congress, an MYPC for a major weapon system must achieve an estimated 12 percent cost reduction, measured in then-year (or "nominal") dollars, relative to a series of annual contracts over the same period.[1] This section discusses how the Air Force estimates future cost reductions when choosing between annual and MYP contracting alternatives, where the Air Force looks for cost reductions, what factors drive contractors' expectations about cost reductions, and where contractors say they planned to achieve cost reductions under past MYPCs for Air Force aircraft.

HOW THE AIR FORCE ESTIMATES COST REDUCTIONS

In principle, the Air Force SPO uses a simple measure of cost reduction for an MYP decision. It requires a prime contractor to estimate its costs of production under two alternative contracts. The contractor uses a series of annual contracts for the period in question to make the first estimate. The contractor uses an MYPC for the same period to make the second estimate. The Air Force SPO monitors the contractor's estimation process and the assumptions and methods used. In the cases we reviewed, contractors consistently had a more detailed understanding of cost estimates than Air Force SPO personnel overseeing their work, but the Air Force played an active role in the final validation of cost reductions. When validation is complete, the difference in cost between these two estimates is, by definition, the cost reduction associated with an MYPC. The SPO uses this difference to judge whether a program should be submitted to higher levels as an MYPC candidate.

[1]Congress judges an MYPC worthwhile if, among other things, moving from one MYPC to the next yields a 10 percent savings in then-year dollars relative to moving to a series of annual contracts, or moving from an annual to an MYPC yields 12 percent savings relative to staying with annual contracts. PL 100-456, 102 stat. 1929, sec. 107 (d)(3).

The Air Force SPO and its contractor must live with the cost estimate they develop for the contractual alternative chosen. The costs that the contractor and SPO negotiate form the basis for the price that the Air Force must pay the contractor. This imposes a strong discipline on the contractor, which will not want these cost estimates to be too low. In turn, SPO monitors work to keep this number as low as possible to ensure continued funding. The countervailing influence of both parties submits the cost estimation process to close scrutiny. This suggests that we can put as much confidence in any cost estimate that the contractor and SPO might have to live with as we would in any other defense contracting context.[2]

An important circumstance can occur in which we do not have such confidence in estimates of MYP cost reductions. Suppose the contractor and SPO agree that they want MYP contracting. Both have incentives to seek such an outcome. Approval of an MYPC binds the Congress and the Air Force to continue funding at a predictable level and reduces certain administrative burdens in a way that benefits both the SPO and the contractor.

If both the contractor and SPO work together to promote an MYPC, then the discipline discussed above disappears. Enough ambiguity exists in costing methods to allow considerable variation in the estimate for the annual contract that they do not want to prevail. Analysts can potentially use different assumptions about future inflation, allocation of overhead costs, schedules of procurement and production, and other factors to alter the estimate, especially if the SPO and contractor work together to produce a cost estimate for the unfavored annual contract. The annual cost can be overestimated to produce a substantial cost reduction estimate that supports the MYPC alternative.

As a result, we must view estimated cost reductions for an MYPC with some caution. Concern over such a bias might help explain Congress's requirement for high estimated cost reductions.[3]

The same forces that encourage the overestimation of cost reductions need not encourage overestimation of an MYPC's total costs. The Air Staff, OSD, and Congress each further reviews and approves or disapproves of the SPO's candidate. These higher levels of organization are motivated to reduce costs because of competing demands for resources for which they are responsible. Commitment to an MYPC precludes alternative uses of funds. Air Staff, DoD, and congressional

[2]This is a strong caveat. All of these cost estimates occur early in the program; actual costs will not be known for years after the MYP contracting decision is made. Cost estimation remains an imprecise activity that must be used with great care.

[3]See the appendix for more discussion on this point.

auditors can and do review cost estimates. However, these higher levels rely primarily on evidence presented by the SPO to make their decisions. As outside actors they are less likely to detect the subtle points that the contractor and SPO would in their day-to-day dealings with one another.

Air Force SPO and contractor personnel agree that cost reduction estimates for the B-1B MYPC are suspect for precisely this reason. An MYPC was one of several acquisition strategies that the Air Force used to keep the projected program costs of the B-1B below a congressionally imposed cap. Once it became clear that the Air Staff, SPO, and contractor wanted an MYPC to ensure that the program continued, estimates of the cost of an annual procurement began to become less reliable. The cost reduction estimate in the Air Force's final submission to Congress differed markedly from the estimates of the four prime contractors involved in assumptions, methods, and final results. Contractor personnel from these primes expressed reservations to us about several of the Air Force's changes in their estimates. Everyone agrees that they had to live with the final cost estimates accompanying the approved B-1B MYPC, but most also suspect that the actual cost reductions were smaller than the official estimates indicated. They suggest that the MYPC was not responsible for many of the cost reductions that did occur.

WHERE THE AIR FORCE LOOKS FOR COST REDUCTIONS

AFSC Pamphlet 800-55 identifies three key places to look for cost reductions:

- Inflation avoidance.
- Vendor procurement.
- Manufacturing.

It also allows for the potential for lesser reductions associated with design/engineering, tool design, support equipment, and other unspecified factors. Let us review how the Air Force thinks about the potential for cost reductions from these sources and some of the issues that arise in seeking such reductions in practice.

Inflation Avoidance

Moving from a series of annual contracts to an MYPC for the same period induces contractors to change the timing of their operations. As explained in Sec. II, contractors use EOQ purchases to procure and

produce items in larger lot sizes under an MYPC, and they tend to do this earlier than under a series of annual contracts over the same period. In the face of inflation, this change in timing leads contractors to procure or produce these items at a lower cost, in then-year dollars, than under an annual contract. The Air Force attributes this difference in cost to inflation avoidance.

It measures this avoidance in a simple way.[4] For each dollar spent, it asks when that dollar would be spent under the MYPC and when it would have been spent in an annual procurement environment. If these times differ, the Air Force looks at the price level expected for each time. It uses a standard DoD Comptroller price index to define the price level expected at different times in the future.[5] If the price level is expected to change between these times, the Air Force adjusts the MYPC expenditure by the change in price level to determine how much would have been spent in an annual environment. This adjustment measures the inflation avoidance that an MYPC offers for this expenditure. Summing such measures across all MYPC expenditures yields the inflation avoidance for the contract as a whole. Contractors use similar methods.

Moving from annual contracting to MYP contracting can reduce the then-year costs of a program, as defined in DoD budgetary authority, and simultaneously increase the total cost of the program to the federal government. That is, the cost "reduction" associated with inflation avoidance, although officially recognized, is typically illusory. The simplest way to think about this is the following.[6] Whenever the Air Force spends an additional dollar, it must come from somewhere; these days, it comes from additional federal borrowing. Hence, spending a dollar today rather than a year from now means that the government

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[4]In practice, the Air Force now uses a Lotus spread sheet to do this. For details, see AFSC Pamphlet 800-55, p. 10-17.

[5]When developing their own estimates, contractors may use this index or others available in the private sector. For example, many contractors consider the Data Resources, Inc. (DRI) military aircraft price index an appropriate industry standard in this role. The Defense Contract Audit Agency used this index as a standard during the mid-1980s.

[6]Government decisionmakers should use discounted dollars to make comparisons among options. Although the discount rate to use is an open question in federal agencies today, the standard within DoD, based on OMB Circular A-94, calls for a rate equal to 10 percent plus the expected inflation rate (Circular A-94, "Discount Rates to Be Used in Evaluating Time-Discounted Costs and Benefits," 27 March 1972). The discussion in the text essentially takes a congressional perspective to say that moving payments forward, for programs in which the delivery schedules for final products do not change, increases the federal deficit without creating any offsetting social benefit. Discounting by the cost of government borrowing can capture this effect on the deficit from a congressional perspective. For a useful discussion of the economic perspective on discounting, see R. Shishko, *Choosing the Discount Rate for Defense Decisionmaking*, The RAND Corporation, R-1953-RC, July 1976.

must borrow additional money a year earlier and pay interest on that money. Because the interest rate typically exceeds the inflation rate, the government is likely to pay more for an item by buying it earlier, even if it succeeds in avoiding inflation.[7]

The Congress is aware of this problem. It requires presentations of present value estimates of cost reductions and has failed to approve MYPC proposals in which most reductions are the result of inflation avoidance. Nonetheless, it continues to rely most heavily on estimates of cost reduction stated in then-year dollars, estimates that include the so-called reductions associated with inflation avoidance.

Vendor Procurement

According to Pamphlet 800-55, "vendor procurement savings are generated by economic order quantity (EOQ) purchases" (pp. 10–18) made by a prime contractor. That is, by purchasing from its suppliers in larger lot sizes than those justified under annual contracts, a prime contractor can potentially reduce the prices that it pays its suppliers for its purchases. Pamphlet 800-55 expects such prices to fall for larger purchases from commercial and military-specification product vendors as a result of "reduced order processing costs, shipping economies, . . . avoidance of minimum order size charges, . . . fewer production line set-ups, better yields, . . . [for electronic devices] less burn-in time and costs," dealing directly with manufacturers for large orders rather than going through a distributor, and perhaps greater competition. Prices fall for larger orders to other subcontractors as a result of "fewer internal production line set-ups, . . . continuous labor learning, . . . increased competition in less complex items, . . . justified use of more productive existing equipment, and . . . investment in more productive equipment (if made a condition of award)" (pp. 10–18).

The documentation that the Air Force requires and receives provides almost no information about the factors above. Essentially, this discussion points to the opportunity for prime contractors to reduce the prices they pay for purchases by buying in larger lot sizes. The Air

[7]For example, suppose the inflation rate this year is expected to be 5 percent. Then buying an extra wrench this year rather than next could reduce its price from $105 to $100. But the government would have to borrow this $100 dollars. Suppose the government pays 9 percent on bonds with a one-year maturity. The government must pay $9 in interest that it would not have to pay if it borrowed the money next year instead of this year. Hence, the total price of buying the wrench is $109 if we buy it this year and only $105 if we wait a year. Avoiding $5 of inflationary costs by using an MYPC actually ends up costing the government $4 after we pay the interest charges for advanced procurement. The Air Force measure of cost reductions through inflation avoidance takes no account of this problem.

Force never examines why such reductions are possible in detail. Neither does the prime contractor. In their contracts, subcontractors often quote their prices to a prime contractor as schedules in which unit prices vary with the total size and flow rate of the order. These price schedules reflect the effects of the factors outlined above.[8] Once such price schedules exist, it is easy to use differences in the procurement schedules to calculate differences in the amounts that a prime would pay its subcontractors under MYPCs and annual contracts. Such differences provide the basis for documenting the cost reductions that the Air Force expects in this area.

Price schedules, of course, are not the only factor relevant to judging the reductions from vendor procurement. Procurement schedules of vendor supplies that differ under annual and MYP arrangements are also central to such reductions. Vendor prices can affect how a prime wants to schedule purchases. Other factors can affect the items that a prime contractor might decide to buy in large lot sizes and ultimately affect the size of the lots that the prime might buy under an MYPC.

For example, the prime's expectations about the design stability of its system affect how many items it will buy at a time from its vendors. Contractors in the cases we studied used EOQ purchases to buy fewer shipsets of components that were not mature enough to ensure that they would be used through a whole procurement or that they believed could be replaced by engineering change orders during the procurement. For example, anticipating a major block change during its second F-16 MYPC, General Dynamics treated procured items affected by the block change differently than those procured items not affected by it.

Similarly, a prime considers the cost of storing items when deciding how many to buy at a time. If the prime purchases materials in bulk, it asks if they will maintain their quality until it needs them for organic fabrication or assembly. The prime asks how much purchased supplies cost to store during this waiting period. It questions whether, if purchased goods remain in storage for a long time, subcontractor warranties will cover them for long enough times to make the warranties worthwhile. Contractors in the cases we studied raised specific examples of all of these issues while explaining their cost reduction estimates. They sometimes approached these questions quite differently. For example, those with government-owned facilities and surplus space expected lower costs of storage than those without. When purchased items immediately became government property, allowing timely payment, contractors worried less about costs of carrying inventories and the government's regulation of these costs.

[8]Because subcontracts are typically fixed-price, prime contractors receive very limited information on the cost structure of their vendors.

These decisions obviously shape procurement schedules for purchased goods. The tradeoffs required to make these decisions are too complex to allow well-documented optimization; they ultimately depend on managers' experience and intuition, factors that they cannot put on paper.[9]

The Air Force and others argue that MYP contracting can help a prime contractor keep vendor prices down by intensifying competition. We heard anecdotal evidence to support this argument, and prime contractors include it in their deliberations as they estimate cost reductions from vendor procurement. Unless a prime contractor actually initiates competition as part of its preparation for an MYPC, however, its estimate of the effects of increased competition must remain subjective.[10] Furthermore, increased competition would generate some benefits under annual contracting or MYP contracting; only the additional benefits allowed by MYP contracting count here. And we found that, given the cost of qualifying additional vendors, prime contractors can be reluctant to initiate competition aimed at generating this marginal benefit until they are fairly sure an MYPC will be approved—that is, until the time has passed when information about the actual effects of competition would be helpful to the decision to adopt MYP contracting.[11] In sum, we can expect estimates of the effects of competition on vendor prices to remain vague and subjective in validations of MYP contracting cost reductions.

One place the Air Force does not and should not typically expect cost reductions in vendor procurement is in MYP contracting between prime and subcontractors. Prime contractors normally do not initiate MYPCs with their subcontractors when they themselves enter an MYP arrangement with the Air Force.[12] Because a prime contractor's MYPC with the Air Force allows it to accelerate purchases without risk, it can use one or more annual contracts, perhaps linked by options, to extract the full EOQ benefits reflected in subcontractors'

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[9]One General Dynamics official suggested that his company no longer really understands how it would do business under annual contracts for the F-16. Officials in companies currently using annual contracts could say the same thing about doing business under an MYPC. The experience and intuition that officials bring to decisions discussed in the text become more tentative when these officials attempt to apply the decisions to a totally new contracting environment.

[10]General Dynamics recompeted its contracts with subcontractors before initiating its first MYPC and achieved substantial reductions in price-schedule quotes.

[11]Most of the contractor officials that we talked to agreed that a prime generally stays with the subcontractors it has, particularly once the subcontractors have invested in development and tooling efforts. For example, the General Dynamics recompetition mentioned above resulted in changing only one subcontractor.

[12]Important exceptions exist. Unlike the other prime contractors reviewed here, G.E. used MYP contractual terms with many of its subcontractors for the B-1B procurement.

price schedules. To the extent that these schedules reflect the subcontractors' cost structures—and we would expect them to for most items—an MYPC between a prime and subcontractor would not create any additional opportunities for mutual gain. Using such price schedules to cover all subcontractor capital and operating costs may not be as direct, from a contracting perspective, as customized contracts indemnifying subcontractors for capital investments that would reduce their production costs. In our discussions, contracting personnel from prime contractors typically dismissed such customized contracts, preferring standard contracts that they could execute quickly with subcontractors. In any case, a prime contractor would not need an MYPC to insert such indemnification arrangements into otherwise standard annual contracts.

Manufacturing

Larger quantity orders can create an incentive for improving the techniques that a prime contractor uses to fill these orders. When this occurs, manufacturing cost reductions result from increased product and manufacturing engineering within the prime's operation. According to Pamphlet 800-55, product engineering can yield reductions by improving the design of a system and the means of producing it ("producibility engineering") or finding more efficient parts and materials for manufacturing components used in the system ("value engineering"). Manufacturing engineering uses industrial engineering to improve the manufacturing process itself and preproduction planning to anticipate problems during manufacture and to improve work measurement and labor productivity programs.

In the cases we examined, we found that contractors expect only fabrication activities to yield this kind of cost reduction. Fabrication activities involved batch operations that lend themselves to cost reductions from rescheduling in a way that assembly activities do not.

Contractor justifications of the cost reductions that they expect from fabrication activities vary widely in their quality and specificity. Justifications submitted to Congress are typically too vague about these considerations to be useful. Internal memoranda and interviews with Air Force and contractor personnel suggest that the Air Force can learn a great deal more about these opportunities of cost reductions than the formal presentations to Congress would suggest. The Air Force routinely scrubs contractor-proposed cost reductions, validating only a portion of them.

But even when viewed at close range, cost reductions in fabrication are hard to judge. Optimizing production schedules requires subtle

judgments about the cost reductions that result from changing the lengths of production runs and the number of setups, changing the scheduling of a complex set of labor categories or machine tools among many tasks, and so on. The contractor officials we talked to all agreed on the kinds of changes that are important, but they could not be precise about how big the changes should be in a particular case. These considerations in turn affect not just production schedules, but the actual costs associated with manufacturing, design/engineering, tooling, support equipment, and other activities organic to the prime contractor. In the end, managers lean heavily on intuition and experience to make many decisions that affect the difference in cost between annual contracts and MYPCs. No one can be sure what the costs would have been if a contractor behaved differently than it did.

Design/Engineering, Tool Design, Support Equipment, and Other Factors

Pamphlet 800-55 is vague about other potential sources of cost reductions. In practice, we have found that most contractors expect to achieve cost reductions in the design/engineering area. They expect much smaller reductions in the remaining categories that Pamphlet 800-55 identifies.

If a weapon system is mature, the Air Force expects little opportunity for cost reductions associated with system design per se. The Air Force appears to identify this potential source of reduction in Pamphlet 800-55 primarily to warn against using it without clear evidence that a contractual alternative is explicitly responsible for code reductions associated with design.

In fact, most of the cases we examined expected cost reductions here.[13] For example, Rockwell based its cost reductions estimate for the B-1B on a belief that an MYPC would stabilize the airframe design by reducing the Air Force's demand for engineering change orders and thereby reduce the costs normally associated with this category. The B-1B did in fact have fewer engineering change orders than might have been expected early in its procurement. But this reduction was only temporary and some observers believe the congressional cap on the program played a larger role in stabilizing the program than MYP contracting. Boeing, however, expected no MYP contracting effect on design stability when it made its cost reduction estimates for offensive avionics in the B-1B. Because the avionics that Boeing used in the B-1B program were already developed before the program began, little

[13]See Table 11 below.

room existed within the program to increase design stability. Most contractors agreed that MYP contracting would reduce the administrative costs of contracting per se and thereby reduce engineering functions associated with drawing up new contracts. But this is a small cost reduction. One contractor simply stated that its cost analysts model engineering costs as a fraction of manufacturing costs; when MYP contracting reduces manufacturing costs, it must also reduce engineering costs in their model.

The Air Force expects most cost reductions associated with tooling to fall into the manufacturing category above. It provides a separate category for a "major new tooling project under the contemplated MYPC" (p. 10-20). Among the cases that we examined, G.E. expected some cost reductions in this area; no one else did.

According to the Air Force, most cost reductions associated with support equipment will be attributed to the inflation avoidance, vendor procurement, and manufacturing categories above. This category is available to cover reductions associated with support equipment that do not fall into these categories. It was not important in the cases that we examined.

"Other" is simply a residual category designed to account for any other cost reductions that might be expected. We discuss them below in connection with Table 11.

Discussion

Pamphlet 800-55's description of potential cost reductions associated with contractual choices is noteworthy in two respects. (1) It does identify the general kinds of savings to look for. Although it is not clear about this in each instance, its intent is to identify cost reductions that are directly attributable to contractual choice, not to, say, productivity-enhancing investments or engineering change orders that would occur in both annual and MYP environments. The pamphlet also suggests which of these cost reductions are worth the most attention. It indicates that inflation avoidance, vendor procurement, and manufacturing are the most promising places to look for cost avoidance.

That said, (2) the pamphlet provides little guidance on how to measure these cost reductions. It never mentions that, although a contractor may be able to greatly reduce vendor-procurement-related costs under an MYPC for some items, it may be able to achieve little or no reductions for others. The same applies to manufacturing. It never mentions overhead costs or how changes in them, presumably identified with the categories listed, should be allowed to differ under various

contractual arrangements. Further, the pamphlet provides few standard accounts and requires almost no documentation on the assumptions and methods that underlie cost reduction estimates. We learned far more from discussions with contractor personnel than we did from any documentation.

Of these issues, perhaps the most important concerns the treatment of overhead costs. In their presentations to the Air Force, some contractors show contractually induced changes in overhead costs as separate categories of cost reductions while others allocate such reductions to the categories above. And, among the cases that we examined, changes in overhead costs vary substantially from one case to the next.

For example, Rockwell expected MYP contracting to increase its overhead costs for the B-1B and identified this change as a separate effect on costs. Rockwell officials explained to us that MYP contracting would reduce their direct costs. Because the B-1B was their primary activity at the time, this would require them to spread overhead expenses over a smaller base, forcing them to raise their overhead rate. The net effect would be a small increase in overhead costs under an MYP arrangement.

General Dynamics, which also identified changes in overhead costs as a separate item in its cost reductions estimate for the second F-16 MYPC, took a very different approach. General Dynamics expected MYP contracting to increase international confidence in the F-16 program, thereby increasing international sales. This would increase the business base enough for General Dynamics to reduce its overhead rate and its overhead costs in an MYP environment.[14]

The other cases that we examined did not break out changes in overhead cost as a separate item. Such changes were simply allocated to categories like those discussed above. For example, Boeing's B-1B contract was a small part of its total operations so that Boeing did not expect changes in the B-1B contract to affect its business base enough to change its overhead rate. It used a constant overhead rate to cost changes in each cost category reported. When it expected costs to fall in vendor procurement, manufacturing, and so on, it allowed overhead costs to fall proportionately.

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[14]General Dynamics implicitly expected its MYPC to have a large effect on international confidence; it included no foreign sales in its business base when costing its annual procurement alternative and included all foreign sales in its business base when costing its MYP alternative. Calculated in this way, the contractually induced change in overhead costs accounted for over 30 percent of its expected cost reductions of $467 million under its MYPC. See Revised Multiyear Exhibit #6 in "Validation of Multiyear Savings Associated with the Production of 720 F-16 Aircraft," General Dynamics, Ft. Worth, Texas, 15 September 1986.

The Air Force approved each of these very different approaches to overhead costs. Pamphlet 800-55 provides no guidance on calculating overhead cost, and documentation accompanying cost reduction estimates offers scant documentation on the treatment of overhead. As these examples suggest, its treatment can have a major effect on estimated cost reductions. The methods used to calculate contractually induced changes in overhead costs deserve close attention.

Given the variations in the treatment of overhead costs in the cases we examined, we might also have expected variation in the treatment of the profit rate.[15] On the one hand, to the extent that MYP contracting reduces the cost base to which we apply a profit rate, we might expect a contractor to seek a higher profit rate on an MYPC than on annual contracts over the same period. On the other hand, to the extent that an MYPC stabilizes design and production rates, we might expect the Air Force to seek a lower profit rate on an MYPC than on annual contracts over the same period, to reflect the lower level of risk involved. To the extent that these arguments varied in strength across cases, we might expect cost reduction estimates to attribute different cost changes to contractually induced changes in the profit rate. We observed no such thing. Air Force and contractor personnel whom we talked to had not observed such claims in other programs either.

COST REDUCTIONS THAT CONTRACTORS EXPECTED TO ACHIEVE

We have cost reduction data on six earlier Air Force aircraft MYPCs, the first and second F-16 MYPCs and the B-1B MYPCs that the Air Force signed with Rockwell, Boeing, Eaton, and General Electric.[16]

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[15]We might also expect changes in cost attributed to contractually induced changes in learning. For example, if MYP contracting could induce a substantial increase in foreign sales, we might expect this increase to push production down the learning curve, inducing some reduction in production costs. While acknowledging that increased foreign sales would have this effect, General Dynamics did not claim such a cost reduction for its second F-16 MYPC. They suggested that it would be small. Officials elsewhere were not familiar with any contractually induced effects on learning large enough to include in estimates of cost reductions.

[16]The KC-10 MYPC did not generate and preserve the data required to include it in this discussion. We used the following sources: (1) "Validation of Multiyear Savings Associated with the Production of 720 F-16 Aircraft (FY86–FY89 Requirements)," Contract F33657-84-C-0247, P00100, 15 September 1986. (2) "Rockwell MYP Validation Package," Memorandum from Carl A. Conley to B1K, 5 August 1985. (3) "Updated Multiyear Exhibit Package, Lots IV–V Offensive Avionics for B-1B," Memorandum for the record from David J. Burkardt, 21 August 1985. (4) "AIL MYP Validation Package," Memorandum from Carl A. Conley to B1K, 7 August 1985. (5) "F101/B-1B Multiyear

The three columns in Table 9 show different ways to look at the savings expected from using MYP contracting in these cases.[17] The first is the most familiar. It shows reductions based on then-year dollars. This is the primary figure that Congress uses to judge the cost reductions associated with an MYPC. None of these contracts would meet the 12 percent criterion that Congress now uses as a threshold value to qualify new programs for MYP contracting. The General Electric B-1B and, perhaps, the KC-10 procurements come closest to this congressional cutoff. Some Air Force officials suggest that General Electric may have overstated this estimate in an effort to promote the success of the B-1B procurement.[18]

Table 9

COST REDUCTIONS EXPECTED FROM MYPCs[a]
(Percent)

MYPC	Then-Year	Constant Year[c]	Present Value[b,d]
KC-10	10–12	—	—
F-16 MYPC I	10.5	—	—
F-16 MYPC II	9.7	9.0	5.5
B-1B Rockwell	9.0	8.5	7.6
B-1B Boeing	11.6	10.8	9.1
B-1B Eaton	5.5	3.7	0.3
B-1B G.E.[e]	11.8	9.4	4.9

[a]Based on data from MYPC-8 displays, "Present Value Analysis."

[b]Present value calculated using 10 percent discount rate.

[c]Constant year savings are based on FY 83 dollars for the B-1B and FY 85 dollars for the F-16.

[d]Present value reductions are based on FY 83 dollars for the B-1B and FY 84 dollars for the F-16.

[e]General Electric figures for B-1B have been adjusted to use the same assumptions used in other B-1B numbers.

Savings (B1P Msg, 081300Z June 84)," Memorandum from Clyde M. Wellington, YXP, to ASD/B1P, 19 June 1984.

[17]The precision shown is that reported in official documents. It does not reflect the level of certainty that anyone associated with the numbers. All estimates but those for the KC-10 and the F-16(I) MYPCs come from the template currently used to justify proposals. Those for KC-10 and F-16(I) MYPCs are inferred from program files

[18]General Electric has submitted other proposals for MYP contracting. The reductions suggested in these submissions fall as low as 7 percent. Some have suggested that, caught in a soft market at the time, General Electric bid low for the B-1B contract, thereby driving down the price it offered under an MYPC and hence offering substantial

The second column adjusts cash flows each year for the expected rate of inflation and produces percentage cost reductions based on constant year or "real" dollars, as of a year early in the MYPC. Each of these is lower than the percentage reduction in then-year dollars. Because inflation during the periods relevant to these contracts was expected to be moderate, the difference between the first two columns is small. When we compare the inflation assumed for the B-1B contracts with the inflation experienced, actual rates were even lower than those assumed. Hence, the best estimates of percentage cost reductions in then-year dollars are probably between the numbers shown in the first two columns for these contracts.[19]

The third column presents the number that we would expect to be preferred under OMB Circular A-94. This directive dictates that, unless it can develop a solid justification for doing something else, DoD should use a real (adjusted for inflation) discount rate of 10 percent to evaluate its resource decisions. Applying such a rate to the cash flows for the cases we studied yields the percentage reductions in the final column. All reductions are positive, verifying that (assuming the estimates are unbiased) we can still justify preferring an MYP to an annual contractual environment when we consider the time value of money. But the rankings of reductions for contracts are different in the first and third columns, suggesting that congressional decisions based on numbers in Column 1 need not yield the same decisions that we would get using Column 3. And even if the rankings were the same, the contractually induced change in timing for the Eaton contract would not have to be much different than it was for its cost reductions to be negative in the third column even though reductions are positive in Column 1.

Table 10 shows the absolute values of expected cost reductions for most of these cases.[20] Again, each column presents reductions in a slightly different way. The first column shows cost reductions in then-year dollars.[21] Comparing these cost reductions with those in the second column, where the numbers are adjusted for expected inflation, shows that despite its small effect in Table 9, inflation accounts for 25

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reductions. But if that is true, General Electric would have presumably made low serious bids for both MYPC and annual contract alternatives if it could not predict the outcome. General Electric argues that the technological maturity of its engine and other factors specific to the B-1B procurement allowed greater MYP contracting cost avoidance than other procurements did.

[19]We cannot make a similar statement about the F-16 program because reductions for that program depend on events that still lie in the future.

[20]The precision shown is that reported in official documents.

[21]The comparable number for the first F-16 MYPC is $350 million.

Table 10

ABSOLUTE COST REDUCTIONS EXPECTED FROM MYPCs[a]
($ millions)

MYPC	Then-Year	Constant Year[c]	Present Value[b,d]
F-16 MYPC II	466.9	358.5	138.5
B-1B Rockwell	828.0	617.4	357.1
B-1B Boeing	125.7	92.4	48.8
B-1B Eaton	105.0	56.0	2.7
B-1B G.E.[e]	209.8	136.2	50.7

[a]Based on data from MYPC-8 displays, "Present Value Analysis."

[b]Present value calculated using 10 percent discount rate.

[c]Constant year savings are based on FY 83 dollars for the B-1B and FY 85 dollars for the F-16.

[d]Present value reductions are based on FY 83 dollars for the B-1B and FY 84 dollars for the F-16.

[e]General Electric figures for B-1B have been adjusted to use the same assumptions used in other B-1B numbers.

to 50 percent of the reported then-year cost reductions. Recall from Table 9 that, in fact, the full extent of this inflation-related cost reduction was probably not achieved for the B-1B contracts. The final column shows the present value of reductions in each program. With the possible exception of the Eaton program, each program displays substantial cost reductions from using the MYP contracting alternative, MYP contracting would still be worthwhile in these cases even if these numbers substantially overstated the cost reductions of MYP contracting.

Table 11 identifies functional activities in a procurement that yield cost reductions. The shares in the figure are based on data on then-year dollars.[22]

The most obvious point these data make is that vendor procurement accounts for the lion's share of real cost reductions in all of these

[22]Specifically, we sum costs from the sources shown and calculate the percentage of each source as a share of this total. Ideally, we would like data on real cost reductions (costs adjusted for inflation), but such data are not available. As reported in the memoranda we used, these figures may or may not include reductions associated with inflation avoidance and overhead adjustments. Excluding these implicitly assumes that they affect each of the sources of reductions shown in the same way. While this may not be exactly correct, we should not be introducing large enough distortions to change our qualitative conclusions.

Table 11

SOURCES OF COST REDUCTIONS, OTHER THAN INFLATION, EXPECTED FROM MYPCs
(Percent)

MYPC	Vendor Procurement	Organic Fabrication	Engineering/ Design	Other	Total
F-16 MYPC I	81	17	3	0	100
F-16 MYPC II	74	12	0	13	100
B-1B Rockwell	67	26	7	0	100
B-1B Boeing	81	7	3	9	100
B-1B Eaton	85	0	6	10	100
B-1B G.E.	74	21	0	5	100

cases. Together with organic fabrication, the other category that the Air Force regulation emphasizes for real reductions, vendor procurement accounts for 86 to 97 percent of all real reductions. Air Force guidance to emphasize these sources of cost avoidance is consistent with the cost reductions expected in these cases.[23]

The second point that stands out in this table is that, beyond this basic pattern, we observe a strange degree of variety. Why, for example, is General Electric the only contractor that expects no cost reductions associated with engineering/design? General Electric states that because engines are evolutionary designs, the B-1B engine drew heavily on earlier designs, and this was a very short contract; it expected little design change during the course of the contract. Perhaps because the Air Force maintains separate annual funding to improve engines over time, funding for design changes was not important to this contract.[24] Documentation filed with the Air Force provides no information on these explanations.

Why is the Eaton contract the only one that expects no cost reductions associated with efficient fabrication? Reductions associated with fabrication are lower for the electronics-oriented Boeing and Eaton contracts than for the others. Perhaps a greater share of value added in electronics systems derives from purchased components than in

[23]Available records suggest that the KC-10 experience was consistent with these numbers. Cost reduction was expected to come from inflation avoidance, vendor procurement, and a more smoothly running production line. Statements in these records are too sketchy to be more specific.

[24]The Air Force does this through the Component Improvement Program (CIP), which supports all engine production programs, annual contract or MYPC.

other systems, leaving a smaller potential for cost reductions from more efficient organic fabrication. Still, it seems surprising to find no reductions at all. Does Eaton use different accounts than the others? Documentation filed with the Air Force provides no easy answers.

Perhaps most interesting of all, why do cost reductions associated with the "Other" category vary so? Are the potentials for cost reductions really so different under different contracts or does imagination and idiosyncratic accounting play a larger role in this ill-defined category? General Dynamics expected no "other" cost reductions in its first MYPC for the F-16, but expected "other" reductions in MYPC II that accounted for 13 percent of total cost avoidance. Rockwell expected no "other" reductions in its B-1B contract, while each of the other B-1B contractors expected substantial and quite different "other" cost reductions. Boeing, for example, expected reductions associated with test and logistics activities similar in character to the reductions it expected in the engineering area. It also expected reductions in "production material," "other labor," and "other costs." Eaton expected cost reductions associated with "product support labor," labor other than that associated with manufacturing or overhead accounts, and "other direct costs" that appear to vary with engineering and product support labor costs. General Electric included cost avoidances associated with "facility improvement and tooling," activities that Air Force officials suggest were in fact unique to General Electric. They also question whether the cost reduction captured here was truly a result of MYP contracting; it may well have resulted from an investment that General Electric would have made in any case and found convenient to associate with the MYPC. General Electric argues that, although the MYPC might not have affected its total level of investment, it did encourage General Electric's management committee to direct investment funds toward the B-1B program, inducing cost avoidance for the program. The key point here, however, is that the official documentation of these cost reductions is scant, leaving little basis to judge how reasonable these cost estimates are or even whether other comparable cost reductions might be equally as reasonable to include.

The bottom line in Table 11, then, is that Air Force guidance is consistent with the categories of cost reductions that dominate the contracts shown here, vendor procurement and manufacturing. This is where we should direct our attention when examining potential cost reductions for future MYP contracting proposals. Cost reductions in the other categories can be large enough to be interesting. But reductions here are so idiosyncratic and poorly documented that they clearly deserve less attention than reductions in the major cost categories of vendor procurement, manufacturing, and, to the extent that then-year

dollars are more important to policymakers than constant-year dollars, inflation avoidance.

SUMMARY

The Air Force negotiates an estimate of cost reduction that would result from using an MYPC with a contractor. We cannot expect to know after the MYPC is complete whether it achieved the cost reduction projected. But the quality of the initial estimate does not necessarily depend on an ability to audit performance based on this estimate. The contractor and the Air Force must live with the cost estimate for the contractual alternative chosen. That gives both parties incentives to negotiate a realistic cost estimate for each alternative unless they both prefer the same contractual alternative. If this occurs, the normal discipline we would expect to get from pitting the contractor and Air Force against one another in negotiations can slacken, yielding biased estimates for the alternative they do not want to be chosen and hence biased estimates of any cost reduction that might come from choosing an MYPC alternative. Many observers believe that this occurred in the B-1B MYPC.

In AFSC Pamphlet 800-55, the Air Force expects the major cost reductions from MYP contracting to come from inflation avoidance, vendor procurement, and manufacturing. These areas in fact yielded the largest expected cost reductions reported in the cases that we studied. The engineering/design area also consistently yielded expected reductions among these cases. The reductions associated with inflation avoidance are probably only rarely real; in the cases that we have observed, the differences in MYP contracting and annual contracting that lead to inflation avoidance actually increased the total then-year dollars that the federal government has had to pay for Air Force procurement. Documentation for all cost reduction is scant, particularly in the material that DoD sends to the Congress for final approval. This is especially true for reductions associated with overhead costs, which contractors in the cases we examined treated in quite varied ways. The contractors, who play the primary role in estimating cost reduction, have a far better understanding of these reduction estimates than the documentation sent to Congress would suggest. Even for contractors, however, many assumptions underlying these estimates are and must remain based on subjective judgment.

The cost reductions expected in the estimates that accompanied proposals for the MYPCs that we studied never achieved the 12 percent threshold that Congress currently maintains. Because these estimates reflected some inflation-related cost avoidance and past MYPCs

expected higher inflation rates than we now expect, it should be even harder to achieve a 12 percent cost reduction today than it was in the past. When we eliminate the effects of inflation, all of the estimates that we examined, discounted or not, expected positive cost reductions. The data presented here, however, do not allow us to conclude that these reductions were large enough to overcome concerns about biases in these numbers or congressional loss of flexibility under MYP contracting.

VI. APPLICATION TO A B-2 MYPC PROPOSAL

This section applies the methods developed above to the B-2 program as specified in the summer of 1990. The Air Force and its contractors have not reached agreement on what a B-2 MYPC would look like if they chose to use that contractual form or what cost reductions it might offer. The environment for the program and important aspects of its conduct are in a constant state of flux. Originally, the program was scheduled to produce 132 aircraft over a five-year period. Since that time, the Secretary of Defense and the Air Force have cut the production quantity to 75 aircraft. Congress and the administration are currently debating the production schedule and rate. If the Air Force proposes the B-2 for an MYPC, the arguments presented would have to be updated to reflect changes in the underlying uncertainties and expectations.

PROGRAM STABILITY

Our analysis views program stability as a composite of requirements, funding, design, and cost.

Requirements Stability

We used simple indicators to characterize the requirements stability of a program being considered for MYP contracting. They include expected changes in the threat environment, consistent service commitment to the requirement, OSD and congressional support, and the existence or expectation of competing technologies. We applied these indicators, as follows, to the B-2 program to illustrate the areas of instability that should be resolved before an MYPC.

As the perception of strategic threat erodes, the B-2 requirement is coming under closer scrutiny. Recent developments in the Warsaw Pact nations have led to a reevaluation of the requirement for a strategic penetrating bomber. As a result, on December 19, 1989, Secretary Cheney ordered a review of stated requirements for aircraft procurements, including the B-2.[1]

[1]"Cheney Orders Reassessment of DoD Strategy, Weapons Systems," *Defense News*. Other aircraft being reviewed are the C-17, the Advanced Tactical Fighter, and the A-12.

Although the Air Force has consistently stated the threat has not diminished, it has reduced the requirement for the B-2 from 132 to 75. Whether this reduction resulted from a reevaluation of the threat, a presumed future reduction in threat, or a response to growing budget constraints does not matter. The Air Force has shown a willingness to reduce the stated production requirement for the aircraft.

Congress has also questioned the need for the bomber given changing world political alignments. For example, Senators Cranston and Leahy introduced a bill in January 1990 to terminate the B-2 bomber program stating, "It is a plane that continues to search for a mission in a world far different from the one in which it was originally conceived."[2] Similar House bills have been proposed. In fact, the congressional support for the program, once rather strong, has grown weak enough that the House Appropriations subcommittee has approved language that would limit the B-2 procurement to 15 aircraft. The Senate support for the program, still stronger than that in the House, is wavering.

Because of the changing world environment, OSD has not yet committed to a stable B-2 production program and Congress has stated that it will stringently review the B-2 program before approval of any full rate production.

Advances in technology do not pose an imminent threat to the B-2 program; as far as we know, it is the most advanced technology available for the penetrating bomber mission. Existing technology, however, does pose a threat. Cruise missiles offer a less costly alternative means to deal with the threat. Many who believe that standoff platforms using cruise missiles can address the threat have questioned the need for a stealth bomber.

In total, the B-2 requirements stability does not stand up against that of the past MYPC programs. Although it has some common ground with the B-1B bomber, it does not now have the service, OSD, and congressional support that the B-1B program attained at the time of the B-1B MYPC proposal.

Funding Stability

We used simple indicators to characterize the funding stability of a program being considered for MYP contracting, including expected changes in the defense budget and historical funding turbulence.

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[2]"Senate Legislation Requests 'Speedy, Merciful' Death of the B-2 Bomber," *Defense News*, January 29, 1990, p. 44.

The outlook for the next several years is for continued budgetary constraint. Congress is faced with difficult choices about national priorities that must be addressed under the constraints imposed by the deficit. The declining urgency of strategic defense needs, given world political events, makes cutting the defense budget a promising source of funds.[3] The B-2 program has already been subjected to costly program stretchouts because of budget constraints.[4] Press coverage of the program has focused on its high cost at a time of budget crisis.[5]

Government support of the program in times of fiscal constraint will, in part, depend on the perceived management of the program. Reports of seemingly indifferent concern by the Air Force or Northrop about program costs can reduce congressional commitment. Those who now stand in opposition to the program have been provided ample political ammunition by reports of poor cost accounting and program management by the Air Force and Northrop.[6] Obviously, reports of excellent program accounting do not make front page headlines.

The current congressional debate over the future of the program provides strong evidence of funding instability. As long as the program was considered "black" and costs were classified, its funding was smooth. As the program became largely unclassified and its cost became more public, the funding commitment became more turbulent.

In sum, the program has shown much greater funding instability than any of the other past MYPCs except the B-1B. However, even

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[3]For instance, *Aerospace Daily* reported on May 9, 1989 in an article titled "Aspin, Quoting $75 Billion Price, Questions B-2 Affordability," that House Armed Service Committee Chairman Les Aspin sent the Secretary of Defense a letter indicating his concern over the value and affordability of the B-2 program.

[4]"B-2 Stretchout Will Cost $3 Billion, Welch Estimates," *Aerospace Daily*, May 5, 1989.

[5]See, for example, "Costly B2 Stealth Bomber To Roll into Public View," *Washington Post*, November 20, 1988, p. A9; "Will This Bird Fly?" *Time*, December 5, 1988, p. 20; "An $80 Billion Bust?" *Newsweek*, December 5, 1988, p. 18.

[6]The General Accounting Office recently found that the Air Force accounting systems were inadequate. See Molly Moore, "Air Force Costs Grossly Understated," *Washington Post*, February 22, 1990, p. 1. The press has reported that the B-2 program had a costly redesign effort in 1983 and that the Air Force requested production commitments before any flights to test the stealth nature of the craft. On October 31, 1988, General Welch announced that the B-2 had a major wing redesign effort several years previously that cost approximately $1 billion: "B-2 Wing Redesign Effort Cost $1 Billion: General Welch," *Aerospace Daily*, October 31, 1989. *Defense News* reported on May 8, 1989 in an article titled "Air Force Will Buy Before B-2 Bomber Is Ready To Fly" that half of the aircraft would be built and delivered before the aircraft had been completely tested. This was based on production schedules before the program stretchout due to budget cuts. Later, "B-2 Stealth Tests," *Aerospace Daily*, January 15, 1990, reported that 20 of the aircraft will be in production before a preliminary assessment of the stealth capabilities. Finally, Northrop recently pled guilty to fraud charges related to the B-2 program accounts. See Molly Moore, "Arms-Fraud Probes Dropped," *Washington Post*, March 2, 1990, p. 1.

the B-1B procurement did not take place in a budget climate as restrained as the current one.

Design Stability

We use simple indicators to characterize the design stability of a program being considered for MYP contracting: program integration responsibility, number of primes, major new technology incorporated, status of flight test program, production runs completed, and number of aircraft completed.

The Air Force used a government-to-prime relationship on the B-2 similar to that used on the KC-10 and F-16. The Air Force established a single prime contractor, Northrop, for the airframe, and another, G.E., for the engines. Northrop oversees the entire procurement, including all other contractors. The government has not taken on the integration role.

The B-2 program, however, is far more technically advanced than any of the other aircraft studied. Northrop's promotional literature on the B-2 describes it as revolutionary.[7] Publicly available information on it indicates that it makes technological advances in several major areas: new avionics; an unprecedented use of new materials, especially composites, in the structure; a new structural design; and stealth capabilities requiring very precise tolerances in manufacturing.[8] The engines, however, are an evolutionary design, based for the most part on a highly successful earlier design.

Until the date of a decision on a B-2 MYPC, we cannot compare the flight test status, production runs completed, or number of aircraft completed on the B-2 with those of earlier MYPCs. That must wait until an actual proposal is submitted, if indeed one is. Currently the program is in the early stages of flight testing, with no production runs completed, and only one aircraft completely built. At this time, the program resembles the testing status of the B-1B when its MYPC was let.

The early commitment evidenced in the B-1B program is unlikely to be repeated for the B-2. Congress mandated that a Systems Maturity Matrix be developed for the B-2 program to gauge its technical maturity. This matrix aligns technical progress milestones with program

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[7]Northrop Corporation, "B-2 Advanced Technology Bomber, a Revolution in Deterrence," Information package, 1989.

[8]See discussions in Michael Brown, "B-2 or not B-2?" *Survival*, July/August 1988, pp. 351–367; Jay Goldberg, "The Technology of Stealth," *Technology Review*, May/June 1989, pp. 33–45; William Scott, "New Design, Production Tools Will Play Key Role in B-2 Cost," *Aviation Week & Space Technology*, December 5, 1988, pp. 18–22.

acquisition milestones on a matrix. It is a management tool developed to ensure that design stability is proven before further production commitments are made. As a result, Congress has approved only low rate production for the B-2 until development flight tests validate the technical performance of the design.

The Congress and the Air Force will use the matrix to determine if an MYPC might be technically feasible. If MYP contracting does not take place until after key tests are successfully performed, then the design certainty of the B-2 will be higher than with the B-1B and a considerable portion of the developmental test program will be complete before an MYPC is considered. But that does not guarantee that the B-2 will have the completed flight test program and years of production experience of the KC-10 and F-16.

Cost Stability

We used simple indicators to characterize the stability of costs for a program being considered for MYP contracting: the requirement stability, funding stability, technical stability, major new manufacturing processes, number of aircraft produced on the full production line, and inflation.

We have already addressed the first three of these indicators for the B-2 program. As long as congressional uncertainty about the program, the size of the procurement, and the production schedule and design instability remains, the cost avoidance from using MYP contracting cannot be reliably estimated.

Northrop has claimed publicly that the manufacturing processes it plans to use to produce the B-2 advance the state of the art. Northrop claims that it has "introduced a revolution in the technology of aircraft design and manufacturing (with the): first extensive use of three-dimensional computer-aided design, highly automated manufacturing processes; largest composite parts ever manufactured."[9]

The aircraft is still in Low Rate Initial Production, meaning the ability to sustain full rate production has not been established.[10] Thus, the cost estimates based on current production must be considered uncertain. Such uncertainty is offset to some extent by a major change in the way Northrop designed its manufacturing process. Unlike most aircraft that rely on prototype production, the first B-2 was produced using the full manufacturing line. Thus, the new manufacturing

[9]Northrop Corporation, "B-2 Advanced Technology Bomber, a Revolution in Deterrence," Information package, 1989.

[10]"Northrop Aims for Rate Production in '93-'94," *Aerospace Daily*, January 22, 1990, p. 115.

technologies will be proven with the first few aircraft built. The rate production, however, remains unproven.

One factor is likely to favor the B-2 relative to earlier MYPCs. Inflation is expected to be lower in the next several years than during past procurements, suggesting that uncertainty about the final then-year cost of the program is lower than it was for earlier procurements. This one factor, however, is unlikely to offset other factors that contribute to cost instability.

Congress is apparently aware of the uncertainty surrounding current cost estimates. Fiscal years 1988 and 1989 authorization language required that the Secretary of Defense set up a cost, performance, and management initiative for the B-2. Fiscal year 1990 language required a separate General Accounting Office assessment of the B-2 program costs.[11] The results of this assessment have been reported in the press, indicating that technical problems have resulted in slowdowns and increased costs.[12] Cost avoidance estimates associated with a program currently experiencing cost growth are inherently unreliable and must be improved before MYP contracting.

CONTRACT TERMS

Our analysis indicates that contracts offer a reliable image of how risky a procurement is. OSD and the Congress can use information from a proposed MYPC and the immediately preceding contract to suggest how much risk remains in a program and where it lies.

- Use of an FPI contract with a high percentage difference between the target cost and the ceiling indicates design or cost uncertainty exists.
- A share line that imposed the least cost overrun risk on the contractor, say 90/10 rather than 60/40, indicates design or cost uncertainty.
- Warranty clauses that limit contractor responsibility and ECP clauses that allow for renegotiation if the government changes the system design indicate the design is unstable and performance remains unknown.
- Extensive and specific EPA clauses indicate the economic outlook is uncertain.[13]

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[11]PL 100-180, section 121 and PL 100-456, section 232.

[12]Molly Moore, "B-2 Costs Could Rise Sharply," *Washington Post*, February 23, 1990, p. 1.

[13]10 USC 2306 and the regulations encourage the use of EPA clauses in all MYPCs.

- Generous indemnification, cancellation, and termination clauses indicate requirements are unstable and the budget is tightening.

Applying these principles, developed in Sec. IV, to a B-2 MYPC proposal means that if instability exists in the program, then we should observe terms in a B-2 MYPC proposal similar to those above.

Perhaps the best places to look for general assessments of remaining risk are the type of fixed-price contract—with or without incentive provisions or successive pricing—and, for incentive contracts, the shape of the share line and the level of the ceiling price relative to the target price. For example, given inherent risks in the B-2 program, it seems reasonable to expect different contractual terms for the engine contract compared with the Northrop contract. General Electric must bear the risk involved only in its single subcomponent, whereas Northrop as the integrator of the airframe must bear the risk of integration of the subcomponents that have not been tested as an integrated unit. The Northrop contract will probably try to allocate most of this risk to the government.

Given the special nature of the requirements instability that the B-2 currently faces, we would expect particular attention to be given to the definition and implementation of cancellation and termination clauses in all contracts. We would expect these clauses to cover as many types of cost as possible including, in the extreme, forgone profits. We should expect trigger events to be carefully defined to discourage any delays, stretchouts, or redefinitions. We should expect these clauses to include language that expedites payment following a trigger event. We should expect indemnification clauses to be crafted carefully to back up these clauses; they would cover events that fall short of the triggers that can induce a cancellation or termination.

The final nature of the warranty clauses should provide useful information on how far the B-2 program has proceeded in achieving design stability. Given the nature of the development testing program, the greatest uncertainties that remain involve total system performance. Any remaining cap in the integrator's contract must be a signal of uncertainty about the system design. Similarly, clauses like those in the B-1B contracts, some of which delayed the date when the Air Force and contractors agreed on final system performance specifications that were to be warranted, would point to design instability. Presumably, this instability is greater the longer the delay in the specification. And design uncertainties relevant to an MYPC become less important once this date passes.

In sum, contractual arrangements provide the means to define and allocate risks in fairly precise ways. As a result, they provide one

useful gauge of what risks remain in a program considered for MYP contracting. Because the terms of any proposed MYPC should be readily available to all relevant players, they provide fairly objective evidence.

Although they are objective, they are not immutable. To the contrary, the fact that they are negotiable is quite important. An MYPC is one way to enhance program stability in and of itself by increasing the costs to the Congress and the Air Force of changing the program plan. Such stability imposes a risk on the government. The government might quite reasonably argue that, to agree to bear this risk, it needs concessions in the contract that relieve the government of certain other risks. A contractor's willingness to do this can provide evidence of its true belief in the inherent stability of the program at the decision point. The requirement that all MYPCs use fixed-price contracts is one reflection of this viewpoint. Other contractual arrangements that split risks between the government and a contractor can be viewed in a similar light.

COST REDUCTIONS

Using insights from Sec. V to evaluate the estimated cost reductions offered in a B-2 MYPC proposal yields the following points.[14]

If an MYPC becomes part of a larger program to control costs in the B-2 program, an effort that makes it clear to the Air Force and its B-2 contractors that an annual procurement environment is not a viable alternative, DoD and Congress should not expect to get useful estimates of cost reductions from Northrop and its B-2 associates.

Northrop and its contractors should concentrate their search for real cost reductions (adjusted for inflation) on vendor procurement, manufacturing, and, to a lesser degree, engineering/design. Real reductions may be expected elsewhere and they deserve attention, but the categories above deserve the closest attention; reasonable uncertainties about these major categories are likely to be as large as the total expected reductions from lesser categories.

Given the way the Air Force calculates the cost reductions associated with inflation avoidance, such reductions are likely to cost the government money, not save money, and aggravate the deficit problem. That will be true so long as interest rates exceed comparable expected inflation rates, a situation we should expect during the period of any

[14]Northrop and its associate contractors have been reviewing the cost reduction that might result from using an MYPC. Classification constraints prevent our discussing them here in any detail.

procurement of the B-2. Congress should be wary of claims that inflation avoidance reduces cost.

Those who evaluate expected cost reductions should give careful attention to assumptions about the ultimate size of the program and the procurement and production schedules that contractors expect under annual contract and MYPC alternatives. Although these assumptions are necessarily subjective, they will drive the cost estimates. Attention to somewhat more objective assumptions about the technological maturity of various subcomponents, the ability to store sensitive materials, and the treatment of overhead costs (even if the B-2 contractors do not break these out as separate categories) is also important.

No one should expect the B-2 procurement to achieve the 12 percent expected then-year-dollar reductions that Congress currently prescribes to approve an MYPC. Expected reductions for all earlier aircraft MYPCs were smaller, and calculated inflation avoidance would not offer reductions as large today as it did earlier. Given its potential size, even with small percentage cost reductions, a B-2 procurement could offer expected absolute cost reductions under an MYPC comparable to those in earlier aircraft MYPCs. The Congress must recognize that, to pursue such reductions, it would make a larger absolute commitment than it has in earlier MYPCs.

SUMMARY

The application of insights from our analysis demonstrates that they, or other reasonable alternatives, can be used to assess future aircraft MYPCs proposals before commitment. Congress, OSD, and the services should develop indicators that can be applied to the issue of program stability. Contractual terms can and should be used as indicators of program stability and readiness to proceed to MYP contracting. And officials should seek more information about the real (adjusted for inflation) cost reduction that an MYPC might offer.

Appendix

MULTIYEAR CONTRACTING, INFORMATION, AND COST

At its core, a multiyear procurement contract that covers deliveries during a given period of years requires the government to decide on a pattern of deliveries for those years earlier than it would under a series of annual contracts. This early decision has two effects:[1]

- It increases the predictability of demand over these years, allowing the contractor to organize the production more efficiently. More efficient production allows the contractor to offer the government a lower price.
- Circumstances can change and the government can potentially accumulate valuable information during this period; thus, the government has less useful information when it makes contract decisions under a multiyear contract than when it does under annual contracts.

Ideally, any choice between multiyear and annual contracts would consider these two effects and determine whether the cost reduction associated with a multiyear contract outweighs the information advantages of using annual contracts. This appendix puts this tradeoff in somewhat more formal language and relates it to the guidelines that Congress uses to review proposed multiyear contracts.

A SIMPLE MODEL

Consider a situation in which we must make two sequential decisions. First, we decide whether to use multiyear or annual contracting to procure a system for the government. Once this decision is made, we then decide whether to let the contract. We can represent this situation in a simple model. In period 1, we decide which contracting

[1]This argument draws on a central insight from Thomas Marschak, "The Role of Project Histories in the Study of R&D," in T. Marschak, T. K. Glennan, Jr., and R. Summers (eds.), *Strategy for R&D: Studies in the Microeconomics of Development*, Springer-Verlag, New York, 1967, pp. 49–139. It also benefits from suggestions by RAND colleague James Dertouzos.

mode to use to effect a delivery in period 2. If we choose a multiyear contract, we immediately choose, in period 1, whether to order the delivery. If we choose annual contracting, we delay this decision until period 2.

Let us assume a simplified world where we have assessed the benefits and costs associated with either contractual form to arrive at a net benefit, which can be positive or negative. We assume that (a) all uncertainty is associated with benefits and (b) realized benefits are independent of the contracting mode. Because of uncertainty, our net benefits for either contractual form have associated probability distributions. Given the increased efficiency of production under MYP contracting, the absolute value of net benefits is greater for MYP contracting than for a series of annual contracts. However, given the reduced information in MYP contracting environment because of the early decision to be made, the probability distribution of net benefits for the MYP contract (M) has greater variance than the annual contract probability distribution (A).[2] To choose between annual and multiyear contracting, we should presumably compare A and M and use the following decision rules.[3]

- We prefer a multiyear contract more the lower the production costs under multiyear contracting relative to those under annual contracting.
- We prefer a multiyear contract whenever the probability of achieving net benefits is great enough so that we do not need the additional information that an annual contract would allow. That becomes more likely the smaller the absolute variance in the net benefit of a multiyear contract compared with that of an annual contract.

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[2]This analysis should use present value in period 1 when comparing annual and multiyear contracting.

[3]Many simplifications are used in this model. We assume only two periods in which to make decisions. This is appropriate for the choice of contracting mode but may understate the information advantage of annual contracts executed over several years. We assume perfect information under annual contracting when a decision to deliver is made. This clearly overstates the information advantage of annual contracting. We assume that the only decision required in period 2 is a go/no-go decision about whether to deliver a specified system or set of systems. This understates the information advantage of annual contracting. We assume that production costs are certain under the alternatives. Experience reveals that this is far from true, but the assumption does not appear to introduce any clear bias. Further examination of these complexities could well yield additional factors that would help us distinguish annual and multiyear contracts. But it is unlikely to invalidate our qualitative conclusions about these two factors.

CONGRESSIONAL GUIDELINES

The above indicates that a rationally motivated Congress is more likely to approve a proposed multiyear contract the larger the expected percentage cost savings offered by the multiyear contract relative to annual contracts and the lower the uncertainty associated with funding, requirements, technical performance, and cost. In fact the guidelines described in Sec. II indicate that this is Congress's intent. If either the percentage cost reductions is small or uncertainty about any of the factors above is large, Congress requires a closer look to determine if the proposed multiyear contract warrants an exception to its guidelines.

The congressional guidelines are not well specified, but in their implementation they appear to say: (a) determine how big the cost reductions would be if things went as expected and then (b) determine how likely things are to go as expected. These points are very close to the two factors identified above.

Although the justifications that accompany multiyear proposals are too terse to be clear, they appear to suggest that, so long as uncertainties about funding, requirements, and technical performance are small, the Congress is likely to approve a multiyear contract because its expected benefits exceed its costs. That is, information about these uncertainties appears to be designed to get at the second set of factors above. Funding uncertainty actually speaks to the opportunity cost to the Air Force of pursuing the new program. If the program's expected net benefit is large and few contingencies appear to exist under which some other opportunity would look even better, funding certainty is high in the sense that the subjective probability placed on achieving benefits is high. Similarly, requirements certainty is high if the proposed program addresses a core mission that is so important it is unlikely to disappear or if it addresses several missions at least one of which will continue to justify a need for the program. When such certainty is high, the subjective probability of achieving benefits is high. And certainties about technical performance are high if the expected performance is good enough that even shortfalls that could occur in the context of the technology being applied are not large enough to threaten the viability of the program or some part of it. Again, high certainty implies a high subjective probability placed on achieving benefits.

When uncertainties are small, Congress also seeks large percentage cost reductions. Why wouldn't *any* cost reductions be approved, so long as the absolute reductions provided covered the administrative costs of reviewing a multiyear proposal? Three answers have been suggested.

First, Congress faces uncertainties that are not captured in the issues that congres ional guidelines require the Air Force to address in a proposal. From a congressional perspective, a multiyear commitment limits access to information that would be available under annual contracting and thereby degrades the quality of *congressional* decisions. Consider congressional decisionmaking during a period of years in which the Air Force has proposed a multiyear contract. Under annual contracting, Congress has the option of contracting for precisely the deliveries specified in the multiyear proposal. However, if immediate circumstances dictate a change, Congress can use these annual contract resources elsewhere, presumably increasing the value (to Congress) of the resources committed. Therefore, from a congressional perspective, a given set of resources is more valuable if committed under annual than under multiyear contracting because of the flexibility it allows Congress in dealing with an uncertain future.

Congress can reflect this perspective by placing a surcharge on any resources committed to multiyear contracting, and that surcharge should rise as uncertainty in the congressional arena rises, increasing the value of information available for decisionmaking under annual but not multiyear contracting. Such reasoning strongly suggests that the cost reductions resulting from the more efficient production that multiyear contracting allows should exceed the opportunity cost that Congress experiences when it allows decisionmaking under multiyear procurement. A simple way to implement such a comparison is to require these cost reductions to exceed some percentage of total costs. That is what Congress requires. By this logic, the required increase in this percentage reduction that has occurred over time could reflect an increasing congressional appreciation that multiyear commitments degrade its decisionmaking capability or simply increasing uncertainty about how Congress should allocate federal funds during each fiscal year in the budget.

Second, Congress may not believe the estimates of cost differences submitted with proposals. Discussion in Sec. V explains the potential for a bias that favors multiyear contracting in cost estimation. There is some evidence in congressional hearings that increasingly demanding requirements for cost reductions over time reflect some congressional doubt that estimated cost reductions will be achieved. Perhaps requiring large percentage reductions places some discipline on the estimators reducing the probability actual cost reductions will be negative. In practice, any such discipline is likely to be crude and could easily exclude programs where substantial absolute cost reductions will be achieved.

Finally, if large absolute reductions can occur when things go well, large absolute losses can occur if things go poorly. That is, approving a program simply because it will achieve $100 million in reductions if things go well does not recognize that this same program could easily lose $200 million if things did not go well. A percentage standard at least recognizes that. Again, however, using a percentage measure to reflect this concern provides a fairly crude assurance that benefits will exceed costs in some sense. Information on the cancellation ceiling, to be compared with the expected cost reductions, would probably be more useful.

Although guidelines that dictate percentage cost reductions may serve all three of these goals, then, the first is the most compelling. Multiyear contracting clearly limits Congress's ability to act, and it is quite reasonable for Congress to demand assurances that such a limitation is worth the cost that Congress perceives in it.

SUMMARY

To choose between annual and multiyear contracting, we must ask whether lower production costs that multiyear contracting provides are worth more than the flexible response to new information that annual contracting allows. Two forms of information are useful in making this comparison—the difference in production costs under annual and multiyear contracting and the probability that information available under annual contracting could avoid a negative outcome that multiyear contracting could not. Congressional guidelines on cost reductions and uncertainty provide just such information. Congressional guidelines on percentage cost reductions seek information about the importance of production cost reductions and their size relative to the cost that Congress experiences when its commitment to a multiyear procurement limits its flexibility. Guidelines on uncertainty address specific factors that could lead to negative outcomes under a multiyear that would not occur under annual contracting.

Saying that congressional guidelines appear to provide useful information does not suggest that they yield consistent congressional decisions about multiyear proposals in any year or over time. In themselves, the guidelines are too vague to define a consistent set of explicit congressional preferences that could be applied to trade off between expected cost reductions and concerns about downside risk. The guidelines are in fact consistent with a wide range of such preferences. Using historical data on congressional decisions, it might be possible to infer more specific information about congressional preferences. Such an analytic activity would take us well beyond the scope of this report.